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ABSTRACT

The data reported were obtained from two investigations carried out by the Australian Council for Educational Research in 1964 and in 1978. Each study was conducted at two levels of the secondary school. A subset of the 1978 samples is considered, which comprises students in government-only schools, so that effective comparisons can be made. Among the findings, it is noted there have not been substantial gains in the average level of achievement in mathematics learning of girls relative to boys over the 14-year period between the tests. Nevertheless, there is a marked change noted over these same years in the degree of involvement and participation by girls in learning mathematics at the upper secondary school level. Movement towards greater equality between the sexes appears to have taken place during the period. When other things which influence achievement in mathematics are taken into account, group sex differences in achievement at the terminal secondary level disappears, in general. It is suggested that if females place more time and involvement in mathematics, .. the level of males, then sex differences in achievement shall gradually disappear. (MP)

TOWARDS EQUALITY: PROGRESS BY GIRLS IN MATHEMATICS IN AUSTRALIAN SECONDARY SCHOOLS

by

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CONTENTS

LIST OF TABLES

7

LIST OF FIGURES

CHAPTER 1

A CHANGING CONTEXT

In the early years of Australian education, arithmetic was generally the only mathematical subject taught to girls. The question of the ability of girls to learn algebra or geometry was really irrelevant: it was simply considered unnecessary for girls to pursue such studies. However, many uncertainties about the mathematical potential of the average girl persist today.

The reason for concern is that a failure by girls to study and succeed in mathematics prevents their admission to many prestigious courses and careers. Inequalities of attainment are thus maintained. At present there is a need for careful investigation and documentation of the achievement by girls in mathematics with a view to discussing whether substantial sex differences really exist, hypothesizing plausible reasons for such differences as might exist, and invoking public awareness of the possible need for remedial action of some kind.

Sex Differences in Achievement

Much has been written about sex differences in mathematical ability and achievement. As far as the early school years are concerned, Fennema has summed up the findings by stating:

> . . . it appears reasonable to conclude that there are no consistent significant differences in the learning of mathematics by boys and girls in the early elementary years. (Fennema, 1974:128)

This also appears to be the conclusion of other reviewers such as Callahan and Glennon (1975) and Fox, Tobin and Brody (1979).

On the other hand, differences during the secondary school years are regularly reported. Maccoby and Jacklin (1974) concluded their comprehensive review of sex differences by summarizing a few differences which are 'well-established'. Among these was the conclusion that, from the age of about 12 to 13 years, boys excel at spatial-visualization and mathematical tasks. Atweh (1980) points out that despite this conclusion many of the studies reviewed did not find significant differences and Tyler (1969) has emphasized that within-sex differences are, in general, substantially larger than between-sex differences.

Callahan and Glennon (1975) have noted that the different results sometimes obtained from different studies have probably reflected the nature of the mathematical tasks involved. There was a tendency for girls to do slightly better than boys on the low level cognitive tasks such as computation, while boys did better on the higher cognitive tasks such as tests of arithmetic reasoning. In the National Longitudinal Study of Mathematics Achievement in the United States, the results showed that for Grades 4 to 8 girls performed better than boys on computation, particularly at Grades 4 to 6, while boys were superior on tests of more complex cognitive skills of comprehension, application and analysis. Their superiority increased from Grades 7 to 10 (School Mathematics Study Group, 1968-1972).

Fennema (1974) also noted that the type of task was extremely relevant when discussing sex differences in achievement. Leder (1979) cited various studies providing evidence that in Australian secondary schools boys were superior to girls in overall mathematics performance. The better performance of girls on routine calculations was outweighed by the superior performance of the boys on more complex tasks. In an American study, Armstrong (1980) reported that 13-year-old girls were in fact better than boys not only at computation but also at complex tasks such as those requiring spatial visualization. However, there were no differences in favour of girls in the twelfth grade in the United States. It certainly eems that an imbalance in performance develops and asserts itself during the secondary school years.

Convincing evidence was reported by Husén (1967) from detailed results of the First IEA Mathematics Study which was conducted in 12 countries including Australia in 1964. Students from two population levels, 13-year-old and pre-university, were tested on specially constructed achievement tests. In general, sex differences in favour of boys were reported in both verbal and computational scores as well as total score at both population levels, although the magnitudes of the differences varied greatly from one country to the next.

The question arises as to whether sex differences in achievement in mathematics change over time. In recent years in many parts of the Western world there has been an increased realization that girls are being prevented from participating in further education and in certain occupations as a consequence of their inability to achieve success in the study of mathematics. The changing attitudes and values of girls and women and of society towards their involvement in careers formerly reserved almost exclusively for men could well have produced changed patterns of participation by girls in the study of mathematics and could also be associated with changes in magnitudes of sex differences in achievement in mathematics. This report uses evidence from the First and Second IEA Mathematics Studies in Australia in 1964 and 1978 to investigate changing patterns associated with sex differences in participation, achievement and attitudes towards the learning of mathematics in Australian schools.

CHAPTER 2

A REVIEW OF PREVIOUS RESEARCH

Few research issues in education have aroused such interest and continuing research efforts as the question of the origins of sex differences in achievement in mathematics. Many research workers have approached their investigations with clear hypotheses. However, they have, generally, completed their inquiries with an acceptance that they have not obtained strong evidence for the true causes of the very substantial sex differences that emerge in achievement and participation in the study of mathematics during the secondary school years in most Western countries.

The Problem of Ability

Different mathematical tasks may well require different intellectual abilities. The major factor related to mathematics learning is general intelligence but this does not help in explaining sex-related differences in mathematics performance (Armstrong, 1975). Verbal ability is also highly important (Aiken, 1971), but as girls usually excel at verbal tasks (Maccoby and Jacklin, 1974) this cannot explain the sex difference either. Sex-related differences also appear consistently in spatial visualization, this time in favour of boys (Maccoby and Jacklin, 1974).

Fennema and Sherman (1977) controlled for mathematics background and general ability in predicting twelfth grade scores from data collected in the ninth grade. Males scored higher on spatial visualization and correlations between mathematics achievement and spatial visualization were as high as correlations between mathematics achievement and a verbal measure. The sex difference in achievement disappeared when spatial visualization was controlled. These authors are not alone in their findings and were not the first to comment on the significance of what may well be a vital ability for much mathematics learning (see, for example, Smith, 1964). In addition, Garai and Scheinfeld (1963) had previously noted that boys appeared able to integrate spatial cues more adequately than girls in their solutions of mathematical and, in particular, geometric problems.

Even if one assumes such differences to be innate as some authors have done (for example, Harris, 1978) teaching could accentuate the differences. Fennema (1977) points out that many mathematical problems can be solved either by the use of symbols or with the assistance of graphs and drawings. If one approach is stressed at the expense of another some students could be inadvertently disadvantaged. If sex differences in achievement in mathematics can be influenced by such teaching factors it would seem reasonable to suggest that differences in spatial ability, cognitive style and other explanatory factors are learned in the first place. For example, Maccoby and Jacklin (1974) discuss the 'masculine' sex typing of scientific and spatial toys which are seldom given to little girls.

Anastasi (1970) discussed the formation of psychological traits. In particular, she considered the view of Ferguson (1956) that abilities emerge through a process of differential transfer. Because cultural factors influence what the child should learn at each age, different environments lead to the development of different ability patterns. If it is accepted that girls and boys are subjected to different environmental influences and encouraged to learn different things it would not be surprising to find sex differences in ability factors. In an investigation of high school students Very (1967) identified two spatial-visualization factors among boys in addition to a general spatial factor found for both sexes. Dye and Very (1968) found that female ability patterns were consistently less differentiated and more difficult to interpret th hose of males. Very (1967) and Aiken (1973) both noted that the differentia ties increased with age and experience and Aiken (1973) also noted that the degree of age differentiation in mathematical abilities varied with the particular social or cultural group studied.

Such theories of differential development of abilities and cognitive styles h an advantage over biological explanations of sex differences in spatial and mathematical abilities, for which there is a lack of empirical evidence and difficulty in accounting for within-sex differences as discussed by Sherman (1977) and Burton (1978). Atweh (1980) suggested that the question of 'ability' itself should be avoided altogether. He noted the confusion over the nature of mathematical ability which is apparent even from the discussion above, and the difficulty of obtaining an operational definition to ensure that different studies are measuring the same thing. He suggested that it was possible and more profitable to focus on achievement differences and to suggest reasons for these differences without employing the construct of ability at all.

Environmental Influences

In the First IEA Mathematics Study (Husén, 1967) the degree and pattern of male superiority varied across countries and this interaction must mean that the differences in performance between males and females cannot be attributed to sex, alone. This most important study provides evidence for hypothesizing a cultural origin of the differences. In the previous section some suggestion was made that environmental influences may shape the development of abilities. However, on the basis of the results of the IEA study it seems reasonable to attempt to link differences in achievement to sex-role perceptions and socialization practices in different countries. These may affect the different responses of males and females to mathematics learning regardless of developed or potential ability.

There is plenty of evidence to suggest that in some parts of the world girls are discouraged or at least not encouraged to be interested in mathematical or scientific pursuits. From a sample of high ability high school students in the United States of America, Poffenberger and Norton (1959) selected two groups: those who expressed a strong liking for mathematics and those who expressed a strong disliking. The first group was equally divided by sex but the second group contained nearly twice as many girls as boys. The group who liked mathematics reported receiving more encouragement from parents and the father's attitude was seen as less favourable by the group that disliked mathematics. Recent studies report similar findings. In the study by Fennema and Sherman (1977), ninth grade girls reported significantly less positive perceptions of their parents' opinions of them as learners of mathematics than did the boys.

Keeves (1972) studied a sample of children in the Australian Capital Territory who were in Year 6 in 1968. Data were also collected on home environment variables and a further study was made in 1969 when these students were at secondary school. There was little difference between the sexes in the child-rearing and socialization practices of the home, for example, in the amount of warmth and language stimulation provided. However, parents reported that boys were given greater freedom of exploration, more emphasis on competition and more encouragement to discuss a wide range of topics. There was also greater pressure on boys to achieve through working at home. There were significant differences between boys and girls in the ambitions expressed by both the mother and father for the student's future education and occupation, and a higher level of ambition was expressed for boys. Subsequently, at Year 7, the boys expressed more favourable attitudes towards mathematics and science than the girls.

Although there is most likely to be a recursive relationship between developed attitudes and achievement (Aiken, 1970), it could be expected that the future performance of girls in mathematics might be influenced before they even begin a serious study of the subject, through the attitudes and expectations that they hold.

Differences in Attitude

In a small study of secondary schools in the United States by Fennema and Sherman (1977), significant sex-related differences in achievement occurred only in those schools in which differences in affective measures were also evident. In particular, girls were less confident than boys in these schools and confidence correlated almost as highly with mathematics achievement as did verbal and spatial ability. It is easy to hypothesize from the preceding discussion that girls might feel less confident about mathematics than boys. In an Australian study reported by Atweh (1980) high school graduates were asked to predict their ability to handle higher-level mathematics. More boys than girls were sure that they would be able to handle higher mathematics even though the mean performance of the groups on mathematics matriculation examinations was identical.

One factor often postulated as a partial explanation of the relatively poor achievement of girls in mathematics is the motive to avoid success (Horner, 1972). This motive is assumed to be a function of a fear that negative consequences such as loss of femininity will result from success in competitive achievement situations. Mathematics is particularly threatening because it is traditionally a male domain. Some rationale for such a construct has been developed above and Maccoby and Jacklin (1974) further review evidence that parents tend not only to encourage their children to develop sex-typed interests but even to discourage them from participating in activities which they considered more appropriate for the opposite sex. A fear of success in such activities clearly could be a consequence of this parental influence.

There is evidence, both direct and indirect, of the effect of this motive to avoid success. In the study by Fennema and Sherman (1977), a principal components analysis of affective measures for each sex produced a separate factor for girls loading only on 'attitude toward success in mathematics' and 'mathematics as a male domain'. For boys, all the attitude measures loaded on the same factor but for girls there was something different about the two measures referred to above. Sherman (1979) also reported on a longitudinal study in which ninth grade girls who subsequently enrolled in a fourth year of theoretical mathematics (Year 12) showed less positive attitudes toward success in mathematics and stereotyped mathematics more as a male domain than did the overall groups of girls with two or three years of theoretical mathematics. Capable girls were afraid of success. They did not drop out but their fear was considered to inhibit their performance.

Fitzpatrick (1978) studied a group of tenth grade girls of above average general ability. A measure of the degree of influence of others' opinions on the girls' goals and motives had a significant effect on a mathematics achievement test, but not on a verbal achievement test. This could be related to 'fear of success'. Finn, Dulberg and Reis (1979) have suggested that the more successful programs for increasing girls' performance in mathematics and science are the ones that rely on older girls to counsel, encourage and tutor younger girls. Confronting girls with the success of others in a 'male' field may be a means of counteracting other influences.

In Australian secondary schools, Leder (1979) found that girls were higher on fear of success measures than boys and the construct was more characteristic of high performing students, especially girls with high educational and vocational intentions. In this study, girls who said they would elect to continue with mathematics were relatively low in 'fear of success'. A finding by Keeves (1972) could also be taken as indicative of the construct. For girls, achievement in mathematics at the sixth grade was negatively related to motivation scores at high school, while for boys a stronger, positive relationship was found.

Investigations of this factor are all quite recent. Women today are moving into fields which were previously reserved for men and it is possible that such a 'fear of success' will become of lesser importance and gradually disappear as people review their perceptions of sex roles.

Apart from being unsure of their ability or afraid of success, the 'messages' girls receive about themselves as learners of mathematics may give rise to a disinterest in the subject. In the First IEA Mathematics Study a number of attitudes were measured. In the international summary of the results, Husén (1967) reported that boys generally showed greater interest in mathematics than girls although differences did not occur on all other scales. The sex differences in interest in this study were generally less in single-sex schools. This could be because of a lack of immediate role conflict for girls in the absence of boys, although other factors might be involved. Differences in achievement were less in co-educational schools where, presumably, equal opportunities for learning existed.

The girls in the study by Fennema and Sherman (1977) saw mathematics as less useful to them than did the boys. Leder (1974) noted that mathematics textbooks tended to be biased toward the traditional interests of men. Until social changes are such that women share the same interests as men this is likely to affect girls' perception of the subject as relevant and useful to them which in turn may prevent them from developing mathematical interests. Fennema (1979) also reported that girls in secondary schools indicated that they did not feel they would use mathematics in the future whereas boys were more likely to report that mathematics was essential for whatever career they planned.

If girls do not regard mathematics as an area of great relevance to them they may not make much effort to reach an achievement goal. Aiken (1970) noted that the prediction of success in mathematics from attitude measures is better for girls than for boys. In the longitudinal study reported by Hilton and Berglund (1974), sex differences in attitudes emerged between the seventh and eleventh grades. More boys perceived mathematics as interesting and as likely to be helpful in earning a living. Boys also pulled ahead in achievement.

Participation

All of the factors discussed could certainly be considered to affect girls' decisions to study advanced mathematics whether or not they are useful in explaining differences in achievement. Armstrong (1980) referred to the influence of the perceived usefulness of mathematics in commenting on the under-representation of females in Year 12 mathematics classes in the United States despite their optimism as 13-year-olds. In several of the studies cited by Fennema and Sherman (1977) even though many girls said they enjoyed mathematics and that mathematics was relevant for their own sex, fewer girls than boys chose to study mathematics at Year 12. The authors regarded this as a fairly convincing case of the negative impact of certain sex rolés on the election of mathematics subjects by capable female students.

Differential participation rates by sex are a confusing issue when differences in achievement are considered. It may not be the most able girls who elect to study mathematics at all and those who do, may not select courses in the same way as boys. Keeves (1973), in an examination of international IEA results, showed that boys were clearly spending more time on the study of mathematics than girls.

In the 1975 edition of their book, Callahan and Glennon (1975) noted that some recent evidence has cast doubt on their former conclusion that beyond the elementary level the achievement of boys in mathematics increased relative to that of girls. Fennema (1974) suggested that some earlier studies failed to control differential rates of enrolment in mathematics courses, and sex differences in achievement disappeared after such control in the study by Fennema and Sherman (1977).

A time span of about 15 years has elapsed between some of the early studies reported here and the later ones. Many social changes in the role of women have occurred during this time and may have narrowed the gaps in attitudes and achievement between males and females. This may be another reason for the inconsistency of findings over time. The studies cited have also involved several different countries and cross-cultural differences may be at least partly responsible for inconsistent results.

Fennema (1979) believes that if the amount and quality of time spent learning mathematics can be somehow equated for males and females, educationally significant sex-related differences in mathematics performance will disappear. Atweh (1980) would probably agree with this in noting that sex differences in achievement begin to appear at about the time that avoidance of mathematics by girls occurs, and in he suggested that both may be subject to the same influences rather than being causally related to one another.

The Present Study

Australia was a participant in the First IEA Mathematics Study in 1964. This study involved two population levels: 13-year-old students and final year mathematics students in government schools in five Australian States. The students provided background information and answered an opinion questionnaire as well as completing carefully constructed achievement tests.

In 1978 the Australian Council for Educational Research conducted the Second IEA Mathematics Study. The same population levels were involved, this time including students from government, Catholic and independent schools in the six Australian States and the Australian Capital Territory. The tests were basically unchanged from 1964 and data were also collected on curriculum changes in the intervening years.

The availability of such data spanning a 14 year time period makes it possible to obtain a quantitative picture of the changing pattern of sex differences in mathematics achievement in Australia. In the present study sex differences in achievement and attitude, at both levels and on both occasions, are investigated and compared although the main focus is on Year 12 students as this is the level at which sex differences seem most likely to occur. Particuar attention is paid to the consequences of changing participation rates and the question of equivalence of the samples of girls and boys. Any observed changes in sex differences in attitude or achievement over time, or variations in these differences across the Australian States will, we suggest, be indicative of environmental influences involving the changing views of women and girls about their roles in Australian society.

CHAPTER 3

THE SAMPLES AND THE TEST INSTRUMENTS

The data reported in this volume were obtained from two investigations that were carried out by the Australian Council for Educational Research in 1964 and in 1978. Every effort was made to ensure that the conditions of testing, the tests used and the samples tested were as similar as possible on the two occasions. The benefits of this correspondence between occasions were that detailed and accurate comparisons could be made. In summary, there were two studies: The First IEA Mathematics Study which was undertaken in 1964, and the Second IEA Mathematics Study which was carried out in 1978. While the 1964 study involved only samples from the government schools in five States, South Australia being unable to participate, the 1978 study involved both government and non-government schools in the six Australian States and the Australian Capital Territory. As a consequence of the fact that non-government schools were involved in 1978, it was necessary to consider a sub-set of the 1978 samples, which have been termed the 'restricted' samples, and which comprised students in the government schools only so that effective comparisons could be made between 1964 and 1978.

The Populations and the Samples

Each study was conducted at two levels of the school populations. It was decided in 1964 to test at two terminal points in schooling. First, it was decided to test at the last point at which all students in an age cohort were still engaged in full-time education, and secondly, to test those students who were currently studying mathematics at the terminal secondary school stage at a level that would enable them to continue with the study of mathematics in institutions of higher education. Accordingly in Australia, as in 12 other countries, it was decided to test at what is referred to as the Population 1 level and comprised all students who were aged 13:0 to 13.11 years at the date of testing. It was also recommended that the date of testing should preferably be within three months of the end of the school year, and as a consequence, although slightly earlier than in other countries, it was decided to undertake the testing in Australia on the first week of August. The target population for the purposes of testing at the Population 1 level was defined in 1964 to be:

> All students of age 13:0 to 13.11 years on 1 August 1964 in normal classes in Year 7, Year 8 and Year 9 in government schools in New South Wales, Victoria, Queensland, Western Australia and Tasmania.

In 1978 the corresponding target population was defined as:

Table 3.1 Achieved Samples and Estimated Response Rates for Populations 1 and 3 in 1964 and 1978 Testing Programs

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Population 1							
1964							
Schools (n)	-	21	19	34	-	18	16
Students (N)	-	644	668	720	-	475	410
Response rates (%)	-	87	78	94	-	72	85
1978							
Schools (n)	14	37	36	41	39	40	30
Students (N)	343	886	853	846	879	819	698
Response rates (%)	69	89	85	88	88	91	78
Population 3							
1964							
Schools (n)	-	14	14	16	-	8	4
Students (N)	-	234	177	243	-	235	199[a]
Response rates (%)	-	91	75	94	-	107	102
1978							
Schools (n)	9	16	19	19	17	20	14
Students (N)	192	677	462	479	413	496	266
Response rates (%)	72	69	84	85	60	96	72

[a] Includes Year 11 and Year 12 students.

All students of age 13:0 to 13.11 years on 1 August 1978 in normal classes in Years 7, Year 8 and Year 9 in all States except the Northern Territory.

It should be noted that these definitions required the testing of some students at primary schools in New South Wales, Queensland and Western Australia in 1964, and in Queensland, South Australia and Western Australia in 1978.

In 1964, a two-stage sampling design was employed, which involved the selection of a random sample of schools at the first stage of sampling, and the selection of a fixed proportion of students, sampled randomly from within these schools, at the second stage. In 1978, a two-stage sampling procedure was also used, but on this occasion schools were selected randomly at the first stage with a probability proportional to the number of 13-year-old students at the schools, and at the second stage, 25 students were chosen at random from each of the selected schools.

At the terminal secondary school level, referred to as the Population 3 level, care was taken to define courses that were equivalent in the States and in which the study of mathematics was an integral part of the students' preparation for subsequent study in higher education institutions. The courses involved on each occasion were specified separately for each of the States and have been recorded in detail in Rosier (1980:5 -2). On both occasions the same sampling design was used, with a random sample of schools selected from each State at the first stage, and with a constant proportion of the mathematics students in these schools selected randomly at the second stage. The first and second stage sampling patterns were held constant within each State, but differed across States in order to achieve samples with an approximately equal number of students from each State.

Table 3.2 Percentage of Male Students in Samples for Populations 1 and 3 in 1964 and 1978 Testing

Percentage recorded	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Population 1							
1964		50	54	53		54	51
1978R		56	54	49		53	56
1978	41	58	53	49	51	53	52
Population 3							
1964		71	7[illegible]	62		61	81
1978R		60	55	61		54	63
1978	57	58	57	59	70	59	65

In Table 3.1 information has been recorded on the number of schools and students in the achieved samples on each occasion and for each population, together with the estimated response rates that were obtained from the program of testing. In general, the response rates were considered to be satisfactory, and there was no evidence of differential response rates between the sexes that would invalidate to a significant extent the results presented in this report. The proportions of male and female students in the samples on the two occasions and for both populations have been represented in Table 3.2. It should be noted, however, that at the Population 1 level there was a shortfall of male students in the total sample for the Australian Capital Territory in 1978 and an apparent excess of male students in the total sample for New South Wales in 1978. At the terminal secondary school level only the South Australia sample would appear to be significantly different from those in the other States in its composition by sex. However, although the Western Australian samples have shown little change between the two occasions in the percentage of males in the samples, it should be noted from the information recorded in Table 3.1 that on both occasions there are few grounds for questioning the high quality of the samples obtained from this State.

Sampling Errors

This report places very little emphasis on significance testing for the establishment of the general results that it reports and discusses. Procedures of detailed significance testing are not very appropriate for large studies where complex samples have been used in the collection of the data. In the main, the report has depended upon the patterns established in the replication of results across the States. Nevertheless, the question of the statistical significance of the results is both important and of interest. The general procedure that has been adopted in the consideration of levels of significance has been to calculate standard score differences and to determine a level of magnitude above which these standard score differences were considered to be significant at the 95 per cent level of probability and below which they were not.

In setting these critical values for the significance of the standard score differences, it is important to recognize that the samples involved a complex sampling design and that the customary formulae associated with simple random samples are totally inappropriate. Furthermore, the comparisons being made have involved the use of sub-samples of male and female students drawn, in the main, from within the same school. At the Population 1 level it was estimated at the design stage that the samples would have sampling errors of the magnitude of about six per cent of a student standard deviation, and at the Population 3 level the corresponding sampling errors would be about 10 per cent of a student standard deviation. It was considered that the errors associated with the achieved samples corresponded closely to those expected from the designs employed, and involved design effects of approximately 3.5, as is consistent with intra-class correlations between the stages in the sample designs of approximately 0.1. These values are based on evidence collected and reported in the IEA studies and have been discussed in more detail by Rosier (1980). As a consequence the critical values of the standard score differences for the testing of significance of the differences between the sexes, or for the testing of differences between the same sex group on the two occasions, would be 0.19 at the Population 1 level and 0.28 at the Population 3 level. In any discussion of the results presented in this report, only those differences that exceeded these critical levels have been considered, except where reference has been made to a consistent pattern of results across all samples and on both occasions.

The Tests

The Mathematics Tests used in these investigations were developed in 1963 for the testing program in 1964, and are the result of co-operative efforts on the part of representatives from the participating countries. The first stage of these procedures involved the completion of curriculum content analysis grids by each country. The countries then submitted items that were appropriate in their schools to assess student performance in the various cells of the grids. A decision was made to use, in the main, questions of a multiple-choice type with five alternative responses provided, although there were some questions, approximately one-sixth of the items, that involved the construction of a response by the students. After field testing of the items in a majority of countries taking part in the study, the final forms of the tests were prepared for use in 1964. The 1964 Mathematics Test for Population 1 contained 70 items, broken down into three sub-tests each of which required one hour of testing time. Thus the total time needed for testing was three hours. In preparing tests for use in 1978 at the Population 1 level, five of the items that had been used in 1964 were omitted because they dealt with Euclidean geometry, and seven new items were added. This report has only been concerned with the 65 items in the tests that were common to the two testing programs.

Table 3.3 Mathematics Test and Sub-test Summary Statistics: Population 1

Test or sub-test	Number of items	Mean[a]	Standard deviation[a]	Reliability KR 20[a]
Mathematics Total	65	26.2	11.1	0.91
Basic Arithmetic	20	9.7	4.4	0.82
Advanced Arithmetic	15	5.9	2.8	0.71
Algebra	19	6.6	3.4	0.70
Geometry	11	4.1	2.2	0.60
Lower Mental Processes	37	16.6	7.5	na
Higher Mental Processes	28	9.7	5.1	na

a Means of the ten values from the 1964 and 1978R State samples.
na not available

At the Population 3 level the tests in 1964 contained 69 items in four sub-tests. Each sub-test required one hour of testing time, and the total time of testing on this occasion was four hours. In 1978, the 69 items were used again, but three items involving probability were added, to form a total test of 72 items. It was recognized that four hours were not required by students to answer the questions in this test. The total time was consequently reduced to three hours, and each sub-test contained 24 items. In the comparisons reported in this volume, however, only the 69 items that were common to the two testing programs have been used.

The tests at both population levels were sub-divided into several sub-tests and details of this allocation of items into sub-tests is provided by Rosier (1980:60-1). The sub-tests that have been considered in this report, together with the number of items in the sub-tests, the average mean values and the average standard deviations of the sub-tests and the reliability (Kuder Richardson 20) have been recorded for Population 1 and Population 3 on Table 3.3 and Table 3.4 respectively. While the geometry, co-ordinate geometry and logic sub-tests at the Population 3 level had relatively few items and the level of reliability of these sub-tests was low, the information provided by these sub-tests has been considered to be worthy of being reported here. It must be

Table 3.4 Mathematics Test and Sub-test Summary Statistics: Population 3

Test or sub-test	Number of items	Mean[a]	Standard deviation[a]	Reliability KR 20[a]
Mathematics Total	69	28.1	9.1	0.86
Algebra	20	8.2	2.9	0.65
Geometry	5	2.9	1.2	0.34
Co-ordinate Geometry	6	3.2	1.3	0.34
Calculus	11	3.1	2.1	0.60
Relations and Functions	12	4.6	2.0	0.50
Logic	6	2.4	1.4	0.43
Computation	33	13.6	4.8	0.77
Verbal Processes	36	14.5	6.2	na

a Means of the ten values from the 1964 and 1978R State samples.
na not available

Table 3.5 Descriptive and Attitude Scales for Population 1 and Population 3

	Population 1			Population 3		
	n	Mean	SD	n	Mean	SD
Descriptive Scale:						
Mathematics Teaching[a]	5	10.0	2.4	4	8.8	2.1
Attitude Scales Towards:						
School and School Learning	7	15.7	3.6	8	16.7	3.7
Difficulty of Learning Mathematics	5	13.0	2.1	4	7.9	2.5
Importance of Learning Mathematics	6	14.3	2.8	6	11.9	2.8
Man and his Environment	4	8.4	1.9	6	10.2	2.4

Note: [a] There were no data for Queensland in 1964 for this scale.

remembered that the test reliability applies to the scores of individual students and the internal consistency of the results for large groups of students would be substantially greater and correspondingly more meaningful.

The Attitude Scales

Prior to preparing the attitude scales for use in 1978, the data collected for Australia in 1964 were re-analysed by factor analytic procedures and one descriptive scale and four attitude scales were developed for further use. Subsequent to the testing program in 19̄ the attitude scales were re-examined for the different State samples on both oc asions and separately for Population 1 and Population 3, and in this way the scales were further refined so that only items that were internally consistent within the scales at each population level were used in the comparisons between the sexes and across the two occasions. Under these circumstances it was not considered necessary to use exactly the same scales for both populations. The scales were all of a Likert type in which students were asked to respond to the items by indicating whether they agreed or disagreed with the statement, or were undecided in their response. For each item a favourable response was assigned the value of 3, a neutral response was assigned the value of 2, and an unfavourable response was assigned the value of 1. The five scales have been briefly described below, and the number of items in each scale, the average mean score, average standard deviation and the average reliabilities of the scales that have been used in this report have been recorded in Table 3.5

1 Descriptive Scale: Mathematics Teaching. This scale was designed to measure the views of the students concerning the approach used by their teachers to the teaching of mathematics. The scale ranged from an approach that emphasized problem-solving processes to one that emphasized rote-learning.

2 Attitudes towards School and School Learning. This scale was designed to measure the students' attitudes to school and school learning. The scale ranged from a strong enjoyment of school and school work to a lack of enjoyment of school and a desire to leave school as soon as possible.

3 Attitudes towards the Difficulty of Learning Mathematics. This scale was designed to measure the students' attitudes concerning the ease with which mathematics was learnt. The scale ranged from an attitude that most people could learn mathematics to an attitude that mathematics could only be learnt by a small elite group of ersons.

4 Attitudes towards the Importance of Mathematics. This scale was designed to measure students' attitudes towards the importance of mathematics for employment or understanding the environment. The scale ranged from an attitude that mathematics was important in a variety of circumstances to the attitude that mathematics was of little use and value in any field.

5 Attitudes towards Man and His Environment. This scale was designed to measure students' attitudes towards the control that man had over his environment. The scale ranged from the attitude that man could control his physical and social environment to an attitude that man was unable to eliminate poverty or solve major problems and mysteries.

The five scales employed in this study were shorter and less stable than might have been expected or desired. Nevertheless, they do provide valuable evidence that is complementary to the information obtained from the achievement tests and the importance of having such data for an investigation of sex differences cannot be gainsaid.

The Questionnaries

Each student provided, in addition, specific information on the following items that have been used in this report: age, sex, father's occupation, and time spent learning mathematics. For further details on the questions employed and the manner in which the information obtained was coded and used, the report by Rosier (1980) should be consulted. Reference to this report would also provide further information on the tests and the attitude scales.

Concluding Comments

While data were available on both occasions on whether on not the school was single sex or co-educational, or whether the students' mathematics teachers were male or female, the interaction between these factors and the sex of the student have not been examined in this report. It is possible that these factors do interact differently for boys and girls to influence their level of achievement in mathematics and such relationships would appear worthy of consideration on a subsequent occasion. This study focuses, in the main, on changes over the period of 14 years from 1964 to 1978 in sex differences in achievement and attitudes towards mathematics in order to investigate direct effects that might be of consequence.

CHAPTER 4

PERFORMANCE IN MATHEMATICS AT THE LOWER SECONDARY SCHOOL

In this chapter the achievement of Population 1 samples on the Mathematics Test and sub-tests is described and discussed. It should be noted that the tests used were developed to assess achievement in mathematics in 12 countries, and hence contained some items that might have been unfamiliar to some Australian students. Since 1964 was a time when the New Mathematics was being introduced into schools at different rates in different parts of Australia, it was not inappropriate that some items should be included in the tests that reflected this emphasis. In 1978, such items had received greater coverage in the schools. However, the area of Euclidean geometry had largely been removed from school courses at the levels of Years 7, 8 and 9 and it was desirable that such items should also be removed from the tests. Rosier (1980) examined relationships between the tests and the school curricula on both occasions.

Results

Table 4.1 records the Mathematics Test mean scores for males and females for Population 1 on each occasion, and also the change scores in standard score units for each sex between 1964 and 1978 for the comparable samples of students in government schools in five States. The significance of the differences in standardized mean scores for each State was achieved according to the procedure outlined in the preceding chapter of this report. All calculations were based on unweighted sample data and scores were not corrected for guessing. Corresponding statistics were also calculated for each sub-test and further details are given in Appendix I. These standardized scores were used in the calculation of sex-difference scores.

The figures in Table 4.2 are also difference scores, based on the same standardized means as the change scores discussed above, but these scores are the standarded differences between the sexes on each occasion. Difference scores for the 1978 total sample are included, however these were calculated using the grand means and standard deviations based only on the 1964 and restricted 1978 samples. The difference scores between sexes on each occasion are also presented graphically in Figure 4.1. A difference of about 0.19 in the standard score differences is required before statistical significance can be attributed to a result at the five per cent level.

Table 4.1 Mathematics Test Mean Scores and Standardized Change Scores for Male and Female Students, Population 1

Mathematics Total (65 items)	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Male							
1964		27.5	28.3	30.7		26.4	23.8
1978R		24.4	24.3	28.3		26.3	23.5
1978	28.3	25.7	25.9	30.0	27.2	27.2	24.0
Change 1978R - 1964		-0.28	-0.37	-0.22		-0.01	-0.03
Female							
1964		27.4	27.4	30.8		25.1	23.6
1978R		26.0	21.8	29.7		26.1	23.3
1978	30.6	26.2	23.2	30.0	26.0	26.6	24.3
Change 1978R - 1964		-0.12	-0.51	-0.10		0.10	-0.03

Note: Change is reported in standard score units. Significant differences in excess of 0.19 standard score units have been underlined.

Table 4.2 Difference Scores Between Standardized Mean Scores of Male and Female Students on Mathematics Test and Sub-tests, Population 1

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Total							
1964		0.01	0.08	-0.08		0.12	0.02
1978R		-0.15	0.22	-0.13		0.01	0.02
1978	-0.21	-0.04	0.24	-0.03	0.11	0.05	-0.03
Basic Arithmetic							
1964		-0.02	-	-0.09		0.02	-0.16
1978R		-0.14	0.14	-0.20		-0.05	-0.09
1978	-0.25	-0.07	0.16	-0.11	0.05	0.00	-0.14
Advanced Arithmetic							
1964		0.11	0.29	0.11		0.25	0.18
1978R		0.04	0.29	0.04		0.00	0.14
1978	0.00	0.11	0.29	0.14	0.29	0.07	0.11
Algebra							
1964		-0.09	-0.06	-0.15		0.00	-0.06
1978R		-0.29	0.12	-0.21		0.03	0.00
1978	-0.30	-0.15	0.12	-0.12	0.03	-0.03	-0.03
Geometry							
1964		0.09	0.18	0.23		0.18	0.32
1978R		-0.05	0.23	0.05		0.23	0.14
1978	-0.09	0.05	0.36	0.09	0.14	0.23	0.05
Lower Mental Proceses							
1964		-0.05	-0.01	-0.05		0.07	-0.[illegible]5
1978R		-0.20	0.13	-0.17		-0.01	-0.07
1978	-0.25	-0.09	0.17	-0.11	0.04	0.01	-0.11
Higher Mental Proceses							
1964		0.08	0.22	0.06		0.16	0.14
1978R		-0.02	0.28	-0.02		0.06	0.16
1978	-0.08	0.06	0.28	0.10	0.18	0.10	0.10

Note: Significant differences in excess of 0.19 standard score units have been underlined. Positive difference scores indicate the superior performance of males and negative difference scores the superior performance of females.

2C

Mathematics Total

Sixty-five items common to the tests on both occasions constituted the Mathematics Total Test. Rosier (1980) reported a general decrease in mean total scores between 1964 and 1978 and it can be seen in Table 4.1 that this decrease was replicated by each sex. Some of the changes were very small, but girls in Western Australia were the only group for whom the direction of change was positive. For both males and females the 1978 total sample consistently achieved a higher mean score than the restricted sample, indicating a slightly better performance by the students in non-government schools.

Victoria was the only State in which the achievement of girls decreased more than that of boys. By reference to Table 4.2 and Figure 4.1 it appears there were few substantial differences between the achievement of males and females even in 1964. Only in Victoria has the difference in favour of boys clearly increased.

Performance on Sub-tests

Basic Arithmetic

There were 20 items in this test. It is clear from Table 4.2 and Figure 4.1 that there were few differences between the sexes in 1964. For the restricted sample in 1978 the girls achieved a higher mean score in Queensland. In the total sample, the girls were clearly better in the Australian Capital Territory. The general impression gained from Figure 4.1 is that there were more differences in favour of girls than boys on this sub-test.

Advanced Arithmetic

There were 15 items in this test. Figure 4.1 reveals a consistent advantage in favour of boys, although this advantage was greater in some States than others. Within States there was little change in the magnitude of the advantage, except in Western Australia where girls made some relative gains.

Algebra

There were 19 items in this test. Figure 4.1 presents a clear picture of State variation in sex differences. There appeared to be no real differences in South Australia, Western Australia or Tasmania. There was a large difference in favour of girls in the Australian Capital Territory in 1978.

Geometry

There were 11 items in this test, but interpretations must be made cautiously as four of the items which were dropped from consideration because of non-compatibility with 1964 were geometry items. As discussed by Rosier (1980) there have been major changes to the geometry syllabuses across Australia and as a result this sub-test was not a particularly comprehensive measure of geometry as taught either in 1964 or 1978.

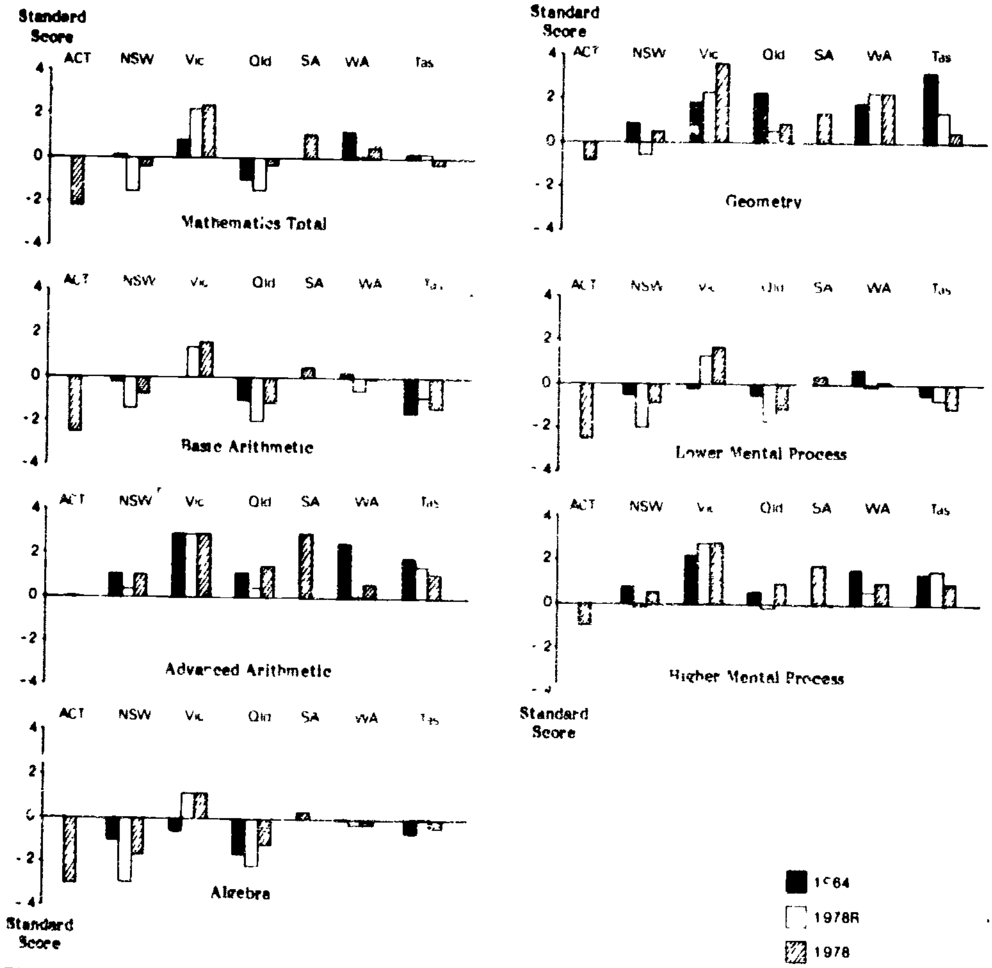

Figure 4.1 **Difference Scores Between Standardized Mean Scores of Male and Female Students on Mathematics Test and Sub-tests: 1964, 1978R and 197 . Population 1**

Rosier (1980) also noted a general decrease in achievement on this scale. There was also a consistent sex difference in favour of boys with the Australian Capital Territory and the 1978 restricted sample in New South Wales being the only exceptions (see Figure 4.1). It is of interest to note that the sex difference in favour of boys decreased in Queensland and quite sharply in Tasmania, yet rose in Victoria.

Lower Mental Processes

This sub-test contained 37 items, some from each of the content sub-tests but mainly from Basic Arithmetic and Algebra. Figure 4.1 indicates that sex differences were generally greater in 1978 than in 1964 with the exception of Western Australia. The differences, particularly in 1978, were generally in favour of the girls, the only clearly different State being Victoria.

Higher Mental Processes

There were 28 items in this test, mainly from the areas of advanced arithmetic, algebra and geometry. Rosier (1980) again reported a general decrease in performance. Figure 4.1 indicates that the sex differences were usually in favour of the boys and have not changed substantially between 1964 and 1978. The largest difference on each occasion occurred in Victoria.

Discussion

Most researchers note inconsistent differences or no difference at all in mathematics achievement between the sexes at the lower secondary level. If any differences exist they consist of an advantage to girls in lower computational tasks and an advantage to boys in tasks involving higher mental processes and spatial knowledge. The findings discussed in this chapter support these generalizations. There was a tendency toward a superiority of girls on tasks involving lower mental processes mainly basic arithmetic and algebra and superior performance by boys on advanced arithmetic and geometry items.

The inconsistent differences across States and the general superiority of boys in Victoria and of girls in the Australian Capital Territory are of some interest. There is, however, little evidence of changes in sex differences in performance across time in any part of Australia.

CHAPTER 5

PERFORMANCE IN MATHEMATICS AT THE UPPER SECONDARY SCHOOL

In this chapter the achievement of the Population 3 samples on the Mathematics Test and sub-tests will be described and discussed. As before, comments will be based on emerging patterns of results. It should be recalled that the tests were developed for use in 12 countries in 1964 and were generally considered appropriate at that time. The use of the tests, without modification in Australia in 1978, but with the addition of three items associated with the topic of probability, might suggest that they were less appropriate on the latter occasion than they were on the former. Rosier (1980) has examined the relationships between the mathematics curricula and the tests on both occasions and it would seem that three tests were slightly more closely related to the curricula of 1978 than they were in 1964. This would appear to indicate that the teaching of mathematics in Australian schools was more closely related to the courses in other countries now than it was formerly. However, it is possible that the courses of other countries might have developed in other directions in the intervening period.

Results

Table 5.1 records the Mathematics Test mean scores for males and females in Population 3 on each occasion and also the change scores in standard score units for each sex between 1964 and 1978 for the comparable samples of students in government schools in five States. All calculations were based on unweighted sample data and scores were not corrected for guessing. Corresponding statistics were also calculated for each sub-test and details are given in Appendix II. These standardized scores were used in the calculation of sex-difference scores.

The data in Table 5.2 are also difference scores, based on the same standardized means as the change scores discussed above, but these scores are the standardized differences between the sexes on each occasion. Difference scores for the 1978 total sample are included. However, these were calculated using the grand means and stardard deviations based only on the 1964 and restricted 1978 samples. The difference scores between sexes on each occasion are also presented graphically in Figure 5.1.

Rosier (1980) indicated that the sampling errors for mean scores for the Population 3 state samples were estimated to be higher than those for Population 1. This meant that a larger difference between mean standard scores was needed before statistical significance could be ascribed to the difference. Rosier suggested that a difference of about 0.28 was needed and this should be remembered when interpreting the pattern of

Table 5.1 <u>Mathematics Test Mean Scores and Standardized Change Scores for Male and Female Students, Population 3</u>

Mathematics Total (69 items)	ACT	NSW	Vic.	Qld	SA	WA	Tas.
<u>Male</u>							
1964		27.5	31.2	27.3		21.9	31.6
1978R		29.4	33.4	29.6		25.9	34.3
1978	24.4	27.4	31.9	29.9	29.3	23.9	34.9
Change 1978R - 1964		0.21	0.24	0.25		0.<u>44</u>	0.<u>29</u>
<u>Female</u>							
1964		26.3	29.2	25.6		18.9	30.5
1978R		24.1	29.8	27.2		20.2	31.0
1978	23.0	25.9	30.0	27.6	26.8	20.7	31.2
Change 1978R - 1964		-0.24	0.06	0.17		0.15	0.06

Note: Change is reported in standard score units. Significant differences in excess of 0.28 standard score units have been underlined.

results. Rosier also noted that overall the changes in mean standard scores on the mathematics tests and sub-tests between 1964 and 1978 were much larger for Population 3 than for Population 1.

Mathematics Total

Sixty-nine items common to the tests on both occasions were used in calculating the Mathematics Total scores. For each of the five States involved in both testing programs, Rosier (1980) reported an increase in the mean standard score for Mathematics Total, indicating a general improvement in mathematics achievement from 1964 to 1978 at this level.

Table 5.1 indicates that improvement in mean scores was greater for boys than for girls. In no State did the female mean score increase as much as the male mean score and, in fact, no female mean score rose by as much as any male mean score. However, only in Western Australia and Tasmania were these changes in mean scores statistically significant. Table 5.1 also indicated little tendency for the inclusion of non-government students in the samples to raise the 1978 mean score.

The evidence of Table 5.2 and Figure 5.1 is clear; there were no differences in favour of girls on mean total score. The sex difference in all States was greater in 1978 than in 1964 and was particularly great in the restricted samples of New South Wales and Western Australia. These two States also had the lowest mean scores for both boys and girls in 1978.

Performance on Sub-tests

There were eight sub-tests contained within the total test of 69 items.

Table 5.2 Difference Scores Between Standardized Mean Scores of Male and Female Students on Mathematics Test and Sub-tests, Population 3

Test/sub-test	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Mathematics Total							
1964		0.13	0.22	0.19		0.33	0.12
1978R		0.59	0.39	0.27		0.63	0.36
1978	0.15	0.17	0.26	0.25	0.28	0.35	0.40
Algebra							
1964		-0.07	-0.03	0.12		0.28	0.27
1978R		0.42	0.30	0.19		0.47	0.37
1978	0.08	0.13	0.25	0.22	0.41	0.20	0.37
Geometry							
1964		0.31	0.23	0.56		0.40	0.22
1978R		0.28	0.18	0.26		0.35	0.18
1978	0.08	0.10	0.08	0.26	0.10	0.21	0.28
Co-ordinate Geometry							
1964		0.20	0.42	0.05		0.10	-0.19
1978R		0.27	0.34	0.05		0.49	0.28
1978	0.17	0.06	0.14	0.01	0.02	0.27	0.31
Calculus							
1964		0.21	0.33	-0.01		0.37	-0.02
1978R		0.49	0.47	0.02		0.68	0.23
1978	0.16	0.17	0.22	0.07	0.11	0.43	0.31
Relations and Functions							
1964		0.20	0.16	0.16		0.22	-0.16
1978R		0.49	0.09	0.11		0.56	0.31
1978	0.15	0.07	0.06	0.07	0.28	0.32	0.37
Logic							
1964		-0.04	0.34	0.04		0.05	0.22
1978R		0.28	0.13	0.15		0.09	-0.16
1978	0.04	0.11	0.09	0.14	0.01	0.01	-0.09
Computation							
1964		0.12	0.03	0.08		0.27	0.08
1978R		0.55	0.41	0.29		0.65	0.28
1978	0.09	0.18	0.28	0.26	0.31	0.34	0.29
Verbal Processes							
1964		0.10	0.30	0.21		0.27	0.12
1978R		0.43	0.26	0.17		0.42	0.31
1978	0.15	0.10	0.16	0.16	0.17	0.25	0.36

Note: Significant differences in excess of 0.28 standard score units have been underlined. Positive difference scores indicate the superior performance of males and negative difference scores the superior performance of females.

Algebra

There were 20 items in this sub-test. Sex differences were generally larger in 1978, especially in the restricted sample. There were no States in 1978 in which girls achieved a higher mean score than boys.

Geometry

There were only 5 items in this sub-test so no major conclusions can be drawn. There were no differences in favour of girls but in all States except Tasmania the sex difference decreased in 1978. As for other sub-tests the difference tended to be less in the total samples than the restricted samples in 1978. The sex difference was especially large in Queensland in 1964.

Co-ordinate Geometry

This sub-test consisted of 6 items, and was probably too short to be of much consequence. Sex differences were inconsistent. However, there were significant sex differences in Victoria, Western Australia and Tasmania, while the only difference in favour of girls was for Tasmania in 1964. The sex difference in favour of boys increased in some States and decreased in others. In all States except Tasmania, the sex differences were again less in the total samples than the restricted samples in 1978.

Calculus

There were 11 items in this sub-test. Sex differences were clearly in favour of boys again and for New South Wales, Victoria and Western Australia this was particularly so for the 1978 restricted samples.

Relations and Functions

There were 12 items in this sub-test. The difference scores were again generally in favour of boys with the exception of Tasmania in 1964. In some States the difference score increased, in others it decreased; there was no consistent pattern. For New South Wales and Western Australia there was again a much larger sex difference in the restricted sample in 1978.

Logic

There were 6 items in this sub-test, probably too few on which to base strong conclusions. Sex differences were not large. The achievement of boys relative to girls increased in New South Wales and Queensland especially in the restricted sample in New South Wales, but decreased in Victoria and in Tasmania where the girls in 1978 appeared to do slightly better than the boys.

Computation

This sub-test contained 33 items, drawn from all content areas except geometry and logic and including arithmetic, trigonometry and sets where there were too few items to constitute sub-tests. There were no sex differences in favour of girls and the advantage to boys was generally larger in 1978 than in 1964.

Verbal Processes

There were 36 items in this sub-test including a probability item and a trigonometry item. The sex differences indicated a general advantage to boys which has increased

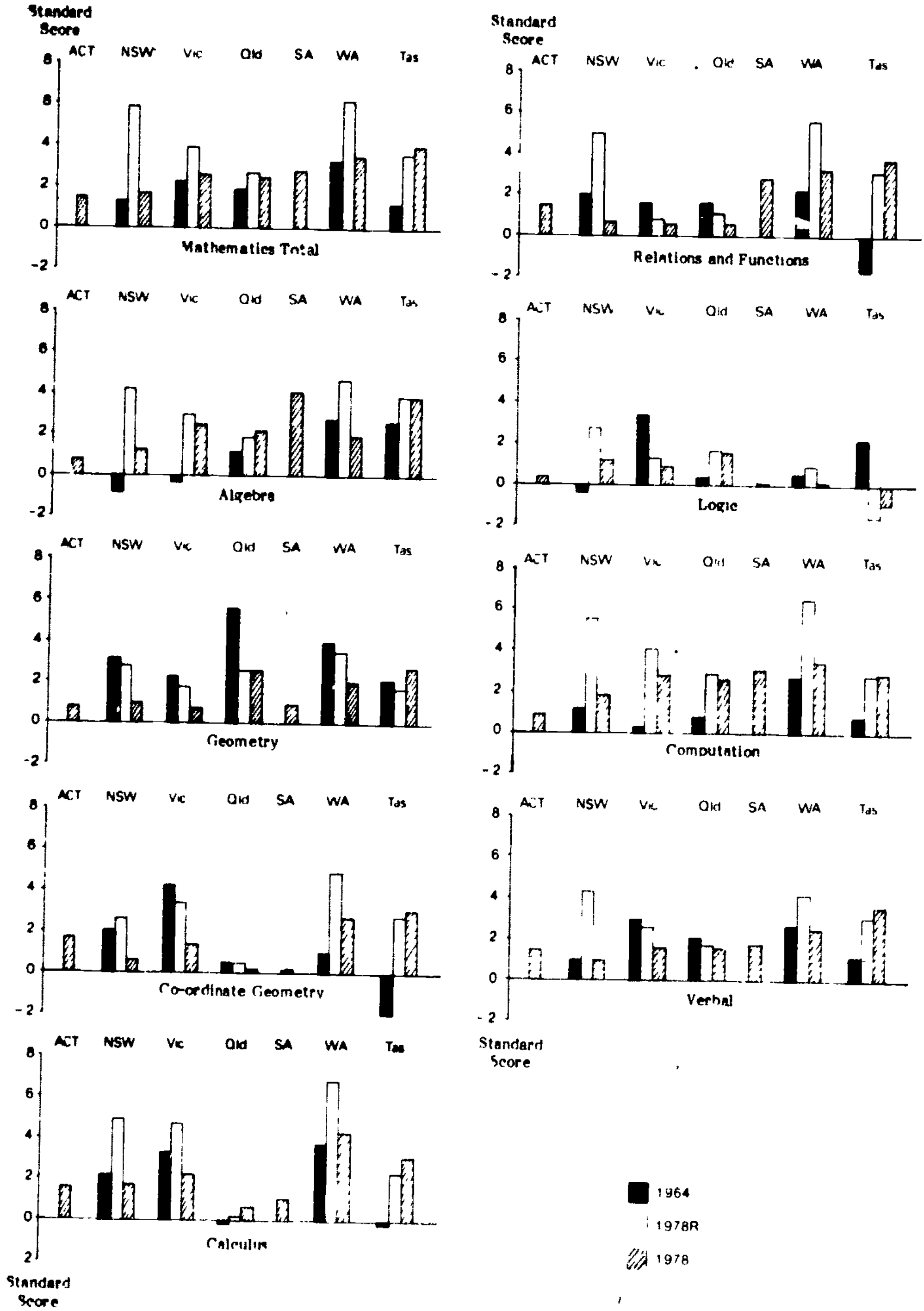

Figure 5.1 Difference Scores between Standardized Mean Scores of Male and Female Students on Mathematics Test and Sub-tests: 1964, 1978R and 1978, Population 3

in some States over time and decreased in others. In New South Wales, Victoria and Western Australia the difference in 1978 was larger for the restricted sample than the total sample.

Discussion

For the Population 3 samples there was generally a clear sex difference in mean score in favour of males which did not occur in Population 1. This was consistent with the popular view that sex differences in mathematics achievement increase at the upper levels of the secondary school. The most interesting result was that on total score and several sub-tests there has been an increase in the sex difference in mean score since 1964. This would appear to be contrary to expectations.

However, these differences could be deceiving and misleading. Many factors have changed since 1964. Regulations in some States concerning the compulsory nature of mathematics at Year 12 have changed (see Rosier (1980) for a discussion of this aspect) and there have been substantial changes to the curricula, changes which are not necessarily uniform across States. The fact that on some sub-tests the sex differences have increased in some States but decreased in others strongly suggests the operation of a range of factors.

There were many interesting differences between States. For example, all differences were quite small in the Australian Capital Territory while in South Australia there were large differences in algebra and relations and functions while the differences were negligible in co-ordinate geometry and logic. The differences in total score did not necessarily mean the same thing in each State. In New South Wales and Western Australia, for example, there was a very large sex difference in computation for the restricted sample in 1978. It would be interesting to determine whether the use of calculators was involved in this difference and whether this had an impact on the total score.

The differences between the restricted and total samples in 1978 were also very interesting. Mean total scores in Table 5.1 suggest it was not only that girls in non-government schools were doing better than those in government schools as one might expect, but also that boys in non-government schools were not doing as well as their counterparts in government schools. The latter might apply only in New South Wales and Western Australia, but in any case it was most interesting that the relative performance of boys and girls was in some way dependent on such factors. This trend did not occur in Tasmania and a number of speculations could be made. Year 12 students attend Matriculation or Senior Colleges in Tasmania and the Australian Capital Territory and these colleges may provide quite different environments from schools in other States.

Table 6.1 Holding Power at Year 12 Level and in Mathematics: 1964 and 1978

		Australian Capital Territory	New South Wales	Victoria	Queensland	South Australia	Western Australia	Tasmania
Grade cohort	1964	77 315		54 103	32 045	18 500	14 932	7 200
	1978	3 418	87 474	69 790	39 595	25 527	22 028	8 579
Number of Year 12 students	1964	21 776		10 986	6 809	2 572	2 895	532
	1978	2 317	31 276	23 046	14 818	9 124	7 543	2 099
Number of Year 12 mathematics students	1964	11 613		5 147	6 067	1 651	2 801	210
	1978	1 540	22 521	11 462	8 326	4 805	4 852	672
Percentage of grade cohort in Year 12	1964	28		20	21	14	19	7
	1978	68	36	33	37	36	34	24
Percentage of Year 12 studying mathematics	1964	53		47	89	64	97	40
	1978	66	72	50	56	53	64	32
Percentage of grade cohort studying mathematics	1964	15		10	19	9	19	3
	1978	45	26	16	21	19	2[illegible]	8
Percentage increase in Year 12 group from 1964 to 1978		54		110	118	255	161	295
Percentage increase in mathematics students 1964 to 1978		107		123	37	191	73	220

CHAPTER 6

HOLDING POWER AND YIELD

In the previous chapter the changes in sex differences in achievement on the mathematics test and sub-tests for Population 3 were discussed and it was found that differences in favour of boys were generally larger in 1978 than they were in 1964. A major problem in assessing the meaning of such a change in the achievement of girls in mathematics relative to that of boys is that participation rates in the subject have changed considerably in recent years. Mean scores as such lose a great deal of their relevance when different proportions of a grade cohort are involved for the two sexes and on different occasions. Obviously the composition of a sample in terms of variables such as ability will change as more of a grade cohort are included in the population.

In an attempt to make allowance for this change in participation rates, this chapter will consider sex differences in terms of the mathematical yield of the schools in each State measured not only by mean score but also by the proportions of the cohort of each sex undertaking the study of mathematics at the Year 12 level.

Holding Power and Achievement

Across Australia from 1964 to 1978, the number of students remaining to Year 12 almost doubled. Accompanying this growth was an equivalent increase in the number of students taking mathematics courses at this level that would enable them to continue with the study of mathematics at tertiary institutions. These increases are recorded in Table 6.1. It should be noted that while in some cases the percentage of Year 12 students studying mathematics has decreased, the percentage of the grade cohort studying mathematics has consistently increased. Some State increases were smaller than others. The extent to which mathematics was studied at the Year 12 level was, in part, a consequence of regulations for matriculation and for entry into tertiary institutions.

In 1964, both the Year 12 group and the mathematics classes in which the students worked were dominanted by males. By 1978 there was an increased proportion of girls, as shown in Table 6.2. Indeed, the retentivity for girls in Year 12 in 1978 was greater than for boys in all States except the Australian Capital Territory and New South Wales.

As the participation rates for Year 12 mathematics grew over the years from 1964 to 1978 there was also an increasing proportion of girls studying mathematics. The calculation of the ratio of male to female students in mathematics classes was difficult since records of the numbers of candidates by sex for the different mathematics examinations at the matriculation level were only available for three States in 1964 and

Table 6.2 Ratio of Male to Female Students at Year 12 Level from 1964 to 1978

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964	1.39	1.44	1.42	1.58	2.07	1.32	1.64
1966	1.79[a]	1.63[a]	1.36	1.45	1.86	1.34	1.49
1968	1.72	1.50	1.26	1.39	1.69	1.25	1.63
1970	1.54	1.48	1.17	1.37	1.55	1.30	1.49
1972	1.26	1.39	1.13	1.34	1.50	1.23	1.34
1974	1.16	1.24	1.01	1.09	1.21	1.14	1.13
1976	1.14	1.12	0.88	1.06	1.07	1.03	1.07
1978	1.10	1.01	0.81	0.98	0.92	0.92	0.92

a The increases in the ratios recorded are a consequence of the introduction of the Wyndham Scheme.

four States in 1978. Consequently, it was necessary to estimate the proportions of male to female students using the numbers of students from the samples used in the IEA Mathematics Studies in 1964 and 1978. It should be remembered that in 1964 the samples were restricted to government schools while in 1978 the samples included both government and non-government schools. The figures in Table 6.3 suggest a possible slight bias in the samples but, nevertheless, provide evidence of the increase in the proportion of girls taking mathematics.

It might be expected that with a greater proportion of the grade cohort remaining at school to Year 12 the average level of performance of Year 12 students would decline. Moreover, since this increase was also reflected in the proportions who were studying mathematics it might be anticipated that the average level of achievement of Year 12 mathematics students would drop significantly over the years 1964 to 1978.

The data recorded in Table 6.4 and plotted in Figure 6.1 tested the presence of a relationship between the proportion of the grade cohort taking mathematics and the mean level of performance of the students. Strong negative relationships existed between mean score and holding power at both times of survey, but the line graph for

Table 6.3 Ratio of Male to Female Students Studying Mathematics at Year 12 Level: 1964 to 1978

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
From official records[a]							
1964			3.2	2.1		2.5	
1978			1.4	1.6	1.5	1.2	
Estimated from samples							
1964[b]		2.4	3.0	1.6		1.6	4.4
1978[c]	1.4	1.5	1.3	1.4	2.0	1.5	1.9

a Not all States maintained records of candidates for Year 12 examinations by sex.

b The 1964 estimates are for government schools only.

c Differences between estimates and official statistics arise from several sources including the definitions of the populations, the execution of the sampling and the difference in the time of year when information was collected.

Table 6.4 Achievement and Holding Power: 1964 and 1978

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
Mean total score		27.2	30.7	26.7		20.7	31.4
Holding power (%)		15	10	19		19	3
1978							
Mean total score	23.8	26.8	30.9	28.9	28.5	22.6	33.6
Holding power (%)	45	26	16	21	19	22	8

Regression			
1964	Coefficient r = -0.82	Gradient b = -0.51	Intercept a = 34.1
1978	Coefficient r = -0.75	Gradient b = -0.25	Intercept a = 33.6

1978 is displaced clearly to the right, indicating not a change in the relationship but a marked gain in average level of achievement in all Australian States. This evidence would seem to clarify the finding of Rosier (1980) that the growth in participation in mathematics courses has not been accompanied by the expected decline in performance as assessed by the mean score on the test.

It was seen from the evidence presented earlier in this chapter that the gain in mean score was not equal for males and females. Girls did not improve to the same extent as boys and in some cases their mean score decreased. Although the participation rate rose for both sexes, the percentage of the female cohort studying mathematics in 1964 was very small and probably highly selective as is shown in Table 6.5. The holding power of Year 12 mathematics courses for girls has, however, increased markedly between 1964 and 1978. Thus, it cannot be directly inferred from mean scores that girls in 1978 have not made equivalent gains to those made by boys.

Mathematical Yield

An allowance for differences in holding power can be made by calculating 'yield' measures of achievement in mathematics (see Husén, 1964 and Postlethwaite, 1967). These measures of yield take into account the proportion of a grade group studying the subject and are concerned with the question: 'How many of these students are brought how far?'

Table 6.5 Holding Power of Year 12 Mathematics for Male and Female Students, 1964 and 1978

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Male							
1964		19.6	13.9	24.8		16.2	6.4
1978	49.7	30.6	17.9	24.3	24.3	25.7	10.1
Female							
1964		8.8	4.6	12.5		11.0	1.6
1978	38.6	21.2	14.9	17.6	13.0	18.2	5.6

Note: These figures were estimated from the samples.

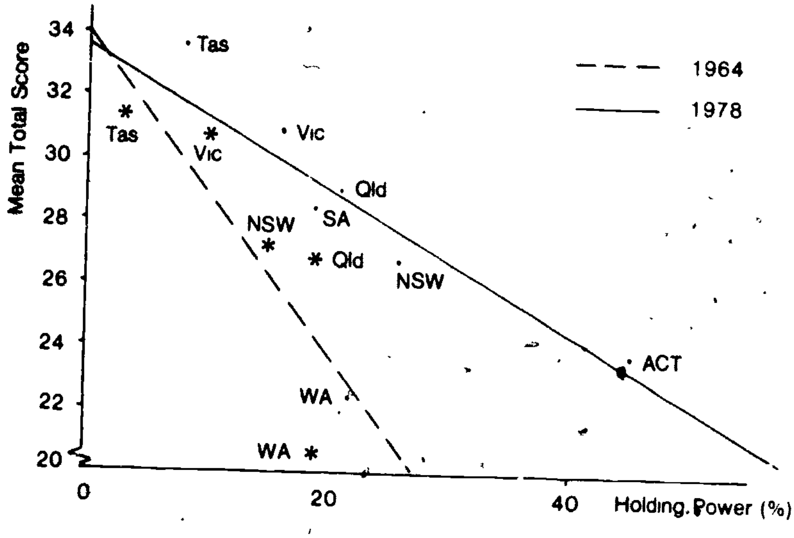

Figure 6.1 Graph of Holding Power against Mean Total Score: 1964 and 1978, Population 3

Postlethwaite (1967, p.79) has drawn attention to some of the assumptions underlying the use of yield procedures. Important assumptions which have been made are as follows:

1 Each correct response to each item is considered to be of equal value irrespective of the difficulty of the item.

2 The total scores are assumed to form an absolute scale. Not only are the intervals along the scale equal, but the zero of the scale is an absolute zero and is equivalent to no effective knowledge of the subject.

3 Those persons who for one reason or another were excluded from the target population because they were not attending school are assumed to have no effective knowledge of the subject.

Insofar as it is possible in some States for a person to train for a professional occupation without having taken a matriculation examination at school it must be acknowledged that the data presented in this report suffers from a degree of bias.

Two indices of yield have been employed in previous research. The first measure of yield is obtained by multiplying the proportion of a grade group in a target population by the estimated mean score for the population to give 'product coefficients'. The second measure of yield involves plotting the cumulative percentile frequencies, expressed as a percentage of the grade cohort in the target population, against the scores on the tests of achievement and regarding the area under the curve as yield. These 'yield graphs' are useful to provide a visual display of the differences and changes in yield.

Table 6.6 Product Coefficient of Yield in Mathematics

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964							
Mean score		27.2	30.7	26.7		20.7	31.4
Proportion of grade cohort (%)		14.9	9.5	18.9		18.8	2.9
Yield coefficient		405	292	505		389	91
1978							
Mean score	23.8	26.8	30.9	28.9	28.5	22.6	[illegible]
Proportion of grade cohort (%)	45.1	25.7	16.4	21.0	18.8	22.0	7.8
Yield coefficient	1073	689	507	607	536	497	[illegible]

In calculating the product coefficients of yield for mathematics in 1964 it must be recalled that the target population consisted of those students at government schools and not students in all schools. Thus the estimates of performance relate to the government schools and the estimates of holding power to the students from all schools. All calculations for 1978 are for the total sample as estimates of holding power were not available for government schools alone.

In Table 6.6, mean scores, proportions of grade cohorts in the target population and product coefficients of yield are recorded for each State. The use of yield coefficients gives a new perspective on measures of achievement in mathematics between 1964 and 1978. Over the 14 year period the yield increased in each State. The increase was greatest in Tasmania where there was a very low level of participation in the study of mathematics at the pre-university level in 1964. In 1978, despite the high mean score, however, the yield for that State remained relatively low. It should also be noted that while the mean score for the Australian Capital Territory in 1978 was relatively low the yield was very high, indicating the general benefits to be gained by holding a high proportion of the grade cohort in mathematics programs.

The purpose of the present discussion is to examine the effects of the increased participation of girls in the study of mathematics at Year 12 level on their achievement. Table 6.7 presents the product coefficients of yield, calculated, as before, using

Table 6.7 Products Coefficients of Yield in Mathematics for Male and Female Students

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Male							
1964		535	434	677		355	202
1978	1213	838	571	727	712	614	353
Increase %		55	32	7		73	75
Female							
1964		231	134	320		208	49
1978	882	549	440	486	348	377	175
Increase %		138	228	52		81	257

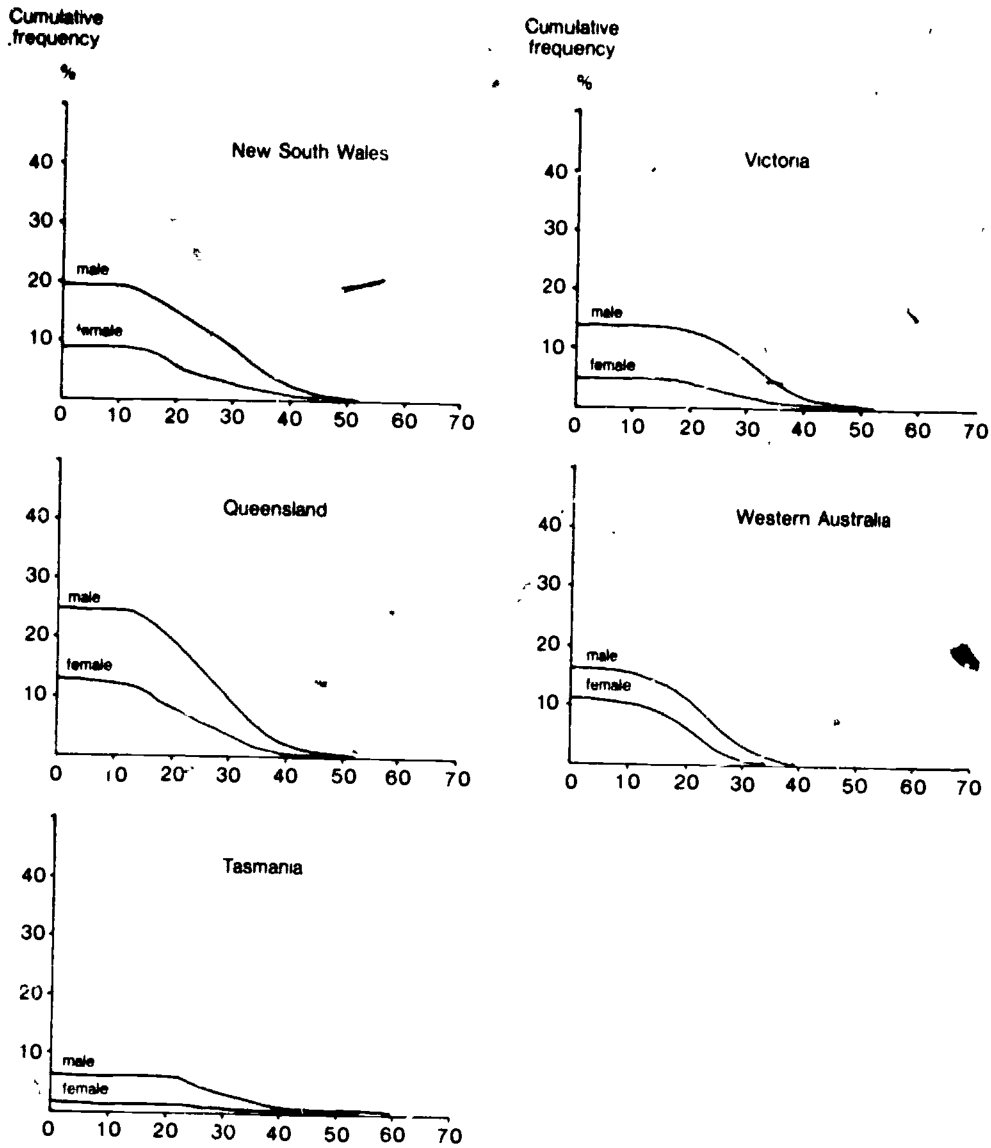

Figure 6.2 Cumulative Frequency Curves of Percentage of Male and Female Students in Year Cohort by Mathematics Total Score: 1964, Population 3

information previously presented for males and females. In addition, the percentage increase in yield from 1964 to 1978 has been calculated and recorded.

Figure 6.2 and Figure 6.3 present the cumulative percentile frequency curves for the yield in mathematics of each of the State systems by sex at the Year 12 level in 1964 and 1978 respectively. The curves have been plotted with scores on the mathematics test ranging from 0 to 69 along the horizontal axis, and with the percentage of the grade group exceeding each score value plotted along the vertical axis. The curves have been smoothed graphically. Yield could also be calculated by counting squares under these curves.

In all cases except that of male students in Queensland the increases in yield were substantial. The Queensland results were due to the high level of performance in 1964 of male students, who represented a large proportion of the grade cohort. This reduced the likelihood of a marked increase in yield.

The increases in yield were greater for girls than for boys. This is shown clearly in the graphs although the difference was small in Western Australia. The evidence available would appear to indicate that across Australia the level of yield for girls in 1978 was roughly equivalent to that for boys in 1964.

The marked increases in yield for female students would be associated with greater opportunity to enter a wide range of tertiary courses and careers. The problem of encouraging girls to proceed and enter these fields is still to be solved.

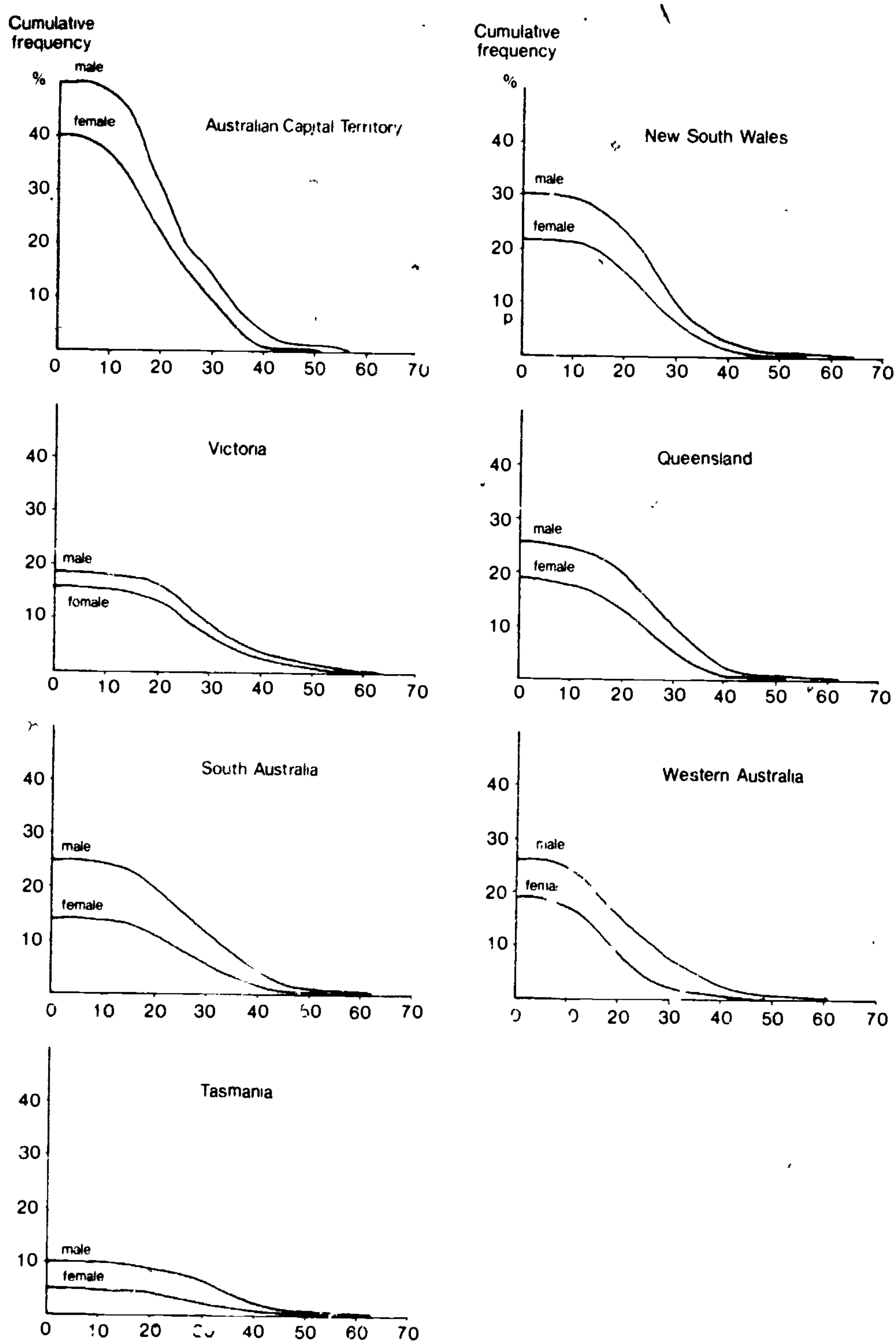

Figure 6.3 Cumulative Frequency Curves of Percentage of Male and Female Students in Year Cohort by Mathematics Total Score: 1978, Population 3

CHAPTER 7

WHEN OTHER THINGS ARE EQUAL

The results presented in the preceding chapter showed that the holding power and yield of girls in mathematics at the Year 12 level increased substantially between 1964 and 1978. This is encouraging as it is a step toward girls providing a wider range of career options for themselves. However, it was also the case that on the total test score and a number of the sub-tests the change in mean score was generally less favourable for the girls. Mean scores for girls remained generally below the corresponding scores for boys and in many cases their relative performance would appear to have deteriorated between 1964 and 1978.

It can be argued that the proportion of the grade cohort taking mathematics had increased sharply for girls, leading to a wider range of ability and thus masking any improvement in the performance of girls. That may well be so, but it is difficult to argue from the existing mean scores that girls at Year 12 can do as well in mathematics as boys.

Such mean scores offer little explanation and are susceptible to confounding influences. The IEA in 1964 defined Population 3 as the students studying mathematics as an integral part of their course for their future training or as part of their pre-university studies; for example, mathematicians, physicists, engineers, biologists, etc. or all those being examined at that level (Husén, 1967, Vol. I:46). In Australia, the definition was then specified precisely in terms of the appropriate mathematics courses in each State. It was revised accordingly in 1978. Courses meeting this requirement within and across States were not all of strictly comparable difficulty. In Victoria, for example General Mathematics is considered an easy alternative to Pure Mathematics and Applied Mathematics, but students of this subject were selected in the samples. Two checks could be made of the data to deal with problems arising. Students indicated the number of hours per week devoted to the study of mathematics at school and teachers indicated their students' opportunity to learn each of the items in the tests. A full description of the Opportunity-to-Learn variable has been provided by Rosier (1980).

In this chapter the contribution to the variance in achievement scores of the sex of the student and other possible explanatory factors has been investigated. Adjusted mean scores for each sex have also been calculated, controlling for the effects of other variables such as the time spent in the study of mathematics and background factors. The method of analysis chosen for these purposes was Multiple Classification Analysis (MCA).

Multiple Classification Analysis

MCA is a technique for examining inter-relationships among several explanatory variables and a dependent variable. The explanatory variables may be at the nominal level of measurement while the criterion must be at the interval level or a dichotomy. Andrews, Morgan, Sonquist, and Klem (1973) cite work that shows one loses very little precision by categorizing a numerical variable into a set of classifications for inclusion in an MCA analysis.

The underlying statistical model and the computer algorithm for the OSIRIS MCA program which was used in this study are fully explained by Andrews et al. (1973). The technique looks at predictors simultaneously and adjusts each to take account of its relationship with the other predictors. For each predictor variable, MCA calculates the mean value of the criterion for the sub-group of the sample corresponding to each category. It also calculates an adjusted mean value of the criterion for each category of each variable, providing an estimate of the effect of a variable as if it were independent of all other explanatory variables in the analysis. MCA assumes that there is no interaction among predictors; that is, the effect of one predictor does not depend upon the level of another. In other words it operates within the context of an additive model. This assumption is important. If there is reason to suspect interaction effects, but no check is made, there is no way to determine whether distortion of the MCA results has occurred.

The Predictor and Criterion Variables

In the present study no attempt was made to establish a causal model to explain achievement in mathematics. The variables entered into the MCA analyses in this study were not assumed to belong to any explanatory collection of factors. They were not necessarily uncorrelated but the purposes of the investigation were merely to determine whether sex had something unique to contribute to an explanation of mathematics achievement at Year 12 and whether the selected predictor variables contributed to the variance in achievement in a similar manner for the two sexes. However, it is still necessary to justify the inclusion of each variable in the analysis.

Mathematics Achievement

Only total score on the test was investigated at this stage of the study. The dependent variable in each analysis was the total score achieved on the 69 items common to the tests in 1964 and 1978. Corrections for guessing were not made.

Hours of Mathematics Learning

As discussed at the beginning of this chapter, the samples included students studying quite a range of courses at the Year 12 level. It could be envisaged, therefore, that some students were at a disadvantage on the tests through non-coverage of the content area of some of the items. Even if all items were written to suit the syllabus of lower-level courses, more time spent on mathematics and exposure to other mathematical topics could feasibly provide an indirect advantage to some. It seemed essential to include a measure of opportunity to learn or time spent on mathematics and it was decided to employ a variable to which students themselves responded concerning the number of hours per week spent in mathematics classes at school. Response codes were collapsed to produce four categories ranging from 1 (low) to 4 (high). Those in category 1 did less than 4 hours of mathematics each week and those in category 4 did 7 hours or more each week.

Father's Occupation

Relationships between measures of socioeconomic level and school performance have been well established. Bryant, Glaser, Hansen, and Kirsch (1974) note that the association holds over a wide range of outcome measures and over a variety of ways in which socioeconomic status is measured. The 'Youth in Transition' study (Bachman, Green, and Wirtanen, 1971) found that a composite index of socioeconomic level including father's occupation, parents' education and measures of family material resources, was the most important family background characteristic for predicting educational attainment. For the purposes of this study father's occupation alone was included as a measure of the home background of the student and regarded as a simple surrogate measure of the educative climate of the home. It was not possible to include measures of the education of the parents of the students for the comparative purposes of this study since it was not possible to collect information on these factors from New South Wales or Queensland in 1964. Bryant et al. (1974) note that using a single, carefully chosen measure of socioeconomic status, such as family income or occupation of head of household, may 'explain' a large proportion of the variance associated with measures of socioeconomic status, and adding additional measures will produce smaller and smaller increments of explained variance. They also discuss, in some detail, the use of father's occupation as a suitable measure and conclude that such a measure is a significant component of socioeconomic status and a valid predictive measure for most academic outcomes. It was more difficult to determine appropriate predictor categories for this variable as different coding systems were used on the two occasions. Rosier (1980) has suggested a recoding strategy for comparative purposes and this was further collapsed to provide five categories for the MCA analyses ranging from 1 (low) to 5 (high). The fathers of those students receiving a score of 1 were engaged in outdoor and labouring occupations while those receiving a score of 5 had fathers involved in professional occupations. Full details of the coding categories are provided by Rosier (1980) and the collapsed categories are recorded in Appendix III.

Age

Bryant et al. (1974) noted that when students were within a one-year age bracket differences attributable to age tended to be trivial. However, there might be a more substantial difference at the Year 12 level where age differences could tend to increase for a variety of reasons. Students recorded their date of birth and this was coded as 'age in months'. For the purpose of the MCA analyses these codes were collapsed into four categories from 1 (low) to 4 (high). Students coded 1 were aged less than 17 years and those coded 4 were age 18 years or more.

Sex

Initially the MCA analyses were run separately by sex using hours of mathematics learning, father's occupation and age as predictor variables. When the analysis was repeated for the entire samples 'sex' became the predictor variable of most interest. The categories were coded 1 for males and 2 for females.

Presentation of Results

The summary tables of results presented later in the chapter include the following statistics:

R^2 (adjusted):	estimate of the proportion of variance explained by the predictor variables if used in an additive model applied to the population from which the sample was drawn. This statistic allows for sample size and the number of predictors and categories.
Eta coefficient:	correlation ratio: square of the ratio of the sum of squares, based on unadjusted deviations from the criterion mean for the explanatory variable to the total sum of squares.
Beta coefficient:	as above, but based on deviations from adjusted means reflecting the influence of the explanatory variable in question while holding constant the other variables.

Problems

Missing Data

The MCA procedure permits missing data for a variable to be retained as a separate category but the presence of missing data does influence the estimation of the MCA adjusted coefficients for the variables in an analysis. It was decided that all cases with missing data on any of the relevant variables should be deleted. The resulting sample sizes are shown in Table 7.1. This table also indicates the percentage of missing data involved in each case in 1978.

Table 7.1 Sample Sizes for MCA Analyses and Percentage deleted for 1978R and 1978 because of Missing Data on One or More Variables, Population 3

		ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964	Male		165	133	151		143	162
	Female		69	44	92		92	37
	Total		234	177	243		235	199
1978R	Male		174	128	158		121	113
	% missing		10.3	2.3	8.7		2.4	6.6
	Female		116	102	101		95	67
	% missing		7.2	4.7	9.0		7.8	5.6
	Total		290	230	259		216	180
	% missing		9.1	3.4	8.8		4.8	6.3
1978	Male	104	373	253	264	250	285	165
	% missing	7.1	8.4	2.3	6.4	8.8	3.7	5.2
	Female	75	248	196	185	129	188	88
	% missing	6.3	8.1	3.4	6.1	7.2	6.0	4.3
	Total	179	621	449	449	379	473	253
	% missing	6.8	8.3	2.8	6.3	8.2	4.6	4.9

Sample Size

Andrews et al. (1973) suggest a simple method for determining the number of cases needed to ensure meaningfulness and stability of the results. For a model of moderate predictive success (40 per cent of the variance explained), the number of cases needed is 10 times the number of degrees of freedom. The number of degrees of freedom is given by:

total number of categories - number of predictors.

More cases are needed for less predictive models. By this reasoning, about 120 cases were needed for each 1964 sample and 110 for each 1978 sample. Table 7.1 shows that this requirement was met for the total samples. For the separate analyses by sex about 110 cases were needed for 1964 and 100 cases for 1978. It may be seen from Table 7.1 that this condition was not always met, especially for the samples of girls. This may affect the stability of some of the estimates.

Results

The dangers of interaction effects in Mutiple Classification Analysis were discussed earlier in the chapter. Among the three predictor variables (excluding sex) used in this study it was possible that interactions might occur, but they seemed unlikely to be of much importance.

The purpose of the analyses was to determine the importance of sex as a predictor and interactions with sex were those of interest. Andrews et al. (1973) suggest the use of sub-group analyses, if variables might be related differently to one another in different sub-groups. To investigate this possiblity separate MCA analyses were run for

Table 7.2 MCA Summary for Mathematics Total Score Related to Sex and other Variables 1964, Population 3

1964		NSW	Vic.	Qld	SA	WA	Tas.
R^2(adjusted)		0.33	0.18	0.18		0.18	0.15
Eta coefficients							
Sex		0.06	0.10	0.10		0.22	0.05
Hours of mathematics		0.57	0.46	0.39		0.43	0.41
Age		0.09	0.13	0.23		0.13	0.07
Father's occupation		0.14	0.10	0.19		0.19	0.14
Beta coefficients							
Sex		0.05	0.05	0.06		0.12	0.07
Hours of mathematics		0.59	0.45	0.39		0.38	0.43
Age		0.09	0.12	0.20		0.09	0.12
Father's occupation		0.14	0.09	0.15		0.15	0.13
Sample size		234	177	243		235	199
1978							
R^2(restricted sample)		0.45	0.28	0.30		0.58	0.04
Eta coefficients							
Sex		0.27	0.19	0.11		0.27	0.13
Hours of mathematics		0.67	0.53	0.53		0.76	0.26
Age		0.14	0.23	0.10		0.11	0.10
Father's occupation		0.23	0.16	0.29		0.14	0.13
Beta coefficients							
Sex		0.09	0.05	0.05		0.02	0.10
Hours of mathematics		0.63	0.49	0.52		0.75	0.24
Age		0.06	0.15	0.06		0.12	0.09
Father's occupation		0.10	0.13	0.22		0.09	0.11
Sample size		290	230	259		216	180
1978R							
R^2(total sample)	0.30	0.26	0.34	0.33	0.37	0.49	0.04
Eta coefficients							
Sex	0.07	0.11	0.11	0.11	0.11	0.15	0.15
Hours of mathematics	0.50	0.51	0.55	0.54	0.60	0.69	0.23
Age	0.16	0.05	0.22	0.10	0.12	0.13	0.11
Father's occupation	0.37	0.18	0.19	0.26	0.17	0.12	0.06
Beta coefficients							
Sex	0.05	0.04	0.01	0.01	0.02	0.04	0.12
Hours of mathematics	0.43	0.49	0.53	0.52	0.60	0.71	0.22
Age	0.12	0.05	0.16	0.08	0.11	0.12	0.11
Father's occupation	0.29	0.11	0.14	0.22	0.13	0.06	0.06
Sample size	179	621	449	449	379	473	253

males and females using three predictor variables: hours of mathematics, age and father's occupation. As for all analyses in the present study the procedure was replicated by State and comparisons were made between 1964, 1978 (restricted) and 1978 (total) samples.

Summary statistics are not presented here but the result was clear; the predictors behaved in a similar manner for the two sexes in each case. The differences that did occur could largely be attributed to instability due to the lower sample sizes for the girls, particularly in 1964. There appeared to be no reason to suspect confusing interaction effects.

In the next stage of the analysis, sex was included in the MCA runs as a predictor variable. In these cases there were no problems with sample size and the summary statistics for 1964, 1978R and 1978 are presented in Table 7.2.

In 1964, after adjustment the model explained 15 per cent to 33 per cent of the variance for sample sizes ranging from 177 to 243. In each State the largest Eta coefficients occurred for hours of mathematics and this variable consistently remained the most important predictor as is shown by the Beta coefficients. There was a sizeable contribution by sex in Western Australia but this was considerably reduced when the other variables were controlled. In other States the contribution of sex was small. The contributions of age and father's occupation remained relatively constant, as seen from the Eta coefficients indicating a small but unique contribution of these variables. The percentage of variance attributable to age was higher in Queensland than in the other States.

In Tasmania prediction was poor and the results varied a little from other States in that the effects of sex, hours of mathematics and age showed suppressor effects when all variables were operating together. This is indicated by the fact that the Beta coefficients were higher than the corresponding Eta coefficients. It must, however, be remembered that the sample of girls from Tasmania was very small and this could have contaminated the results.

In general, it can be concluded that of the variables selected as predictors, sex contributed least to an explanation of the variation in mathematics achievement. It could not be reasonably claimed that in 1964 girls did not do as well on the tests as boys simply because they were girls. Their achievement differed from that of boys in other important respects.

With the exception of Tasmania the model explained more of the variance for the restricted sample in 1978 than in 1964. There was apparently something quite different happening in Tasmania which this model was unable to identify. Even so the contribution of sex decreased when allowance was made for the other variables.

Hours of mathematics was again the prominent variable. Age retained some explanatory value, particularly in Victoria and in Western Australia; in the latter case the Beta value was, in fact, marginally greater than the Eta value. Father's occupation explained a noticeable percentage of variance in each State and retained its importance in Queensland after controlling for the effects of the other variables.

The clearest point is that sex had very little to contribute for the 1978 restricted sample after controlling for the influence of hours of mathematics, age and father's occupation. Initially sex appeared to be a variable of considerable importance, as indicated by the Eta values, especially in New South Wales and Western Australia, but

Figure 7.1 Mathematics Total Related to Sex, Adjusted for Hours of Mathematics Learning, Age, Father's Occupation: 1964, 1978R and 1978, Population 3

Table 7.3 Mean and Adjusted Mean Scores of Male and Female Students Controlling for Hours of Mathematics, Age and Father's Occupation, Population 3

			ACT	NSW	Vic.	Qld	SA	WA	Tas.
1964	Mean scores	Male		27.5	31.2	27.4		21.9	31.6
		Female		26.3	29.2	25.6		18.9	30.4
	Adjusted Mean scores	Male		26.8	30.9	26.3		21.3	31.7
		Female		27.9	30.0	27.3		19.7	30.1
1978R	Mean scores	Male		29.3	33.4	30.1		25.9	33.9
		Female		23.9	30.0	27.9		20.4	31.1
	Adjusted Mean scores	Male		27.9	32.3	28.9		23.7	33.7
		Female		26.1	31.4	29.8		23.3	31.4
1978	Mean scores	Male	24.7	27.6	31.8	30.2	29.4	23.9	34.6
		Female	23.1	25.6	29.7	28.1	27.1	20.8	31.3
	Adjusted Mean scores	Male	24.5	27.0	30.8	29.2	28.5	22.3	34.3
		Female	23.4	26.4	31.0	29.4	29.0	23.2	31.8

the Beta values showed that the effect of sex was largely illusory.

When the total sample for 1978 was considered the model remained unsuitable for interpreting the results in Tasmania. Father's occupation was an important predictor, especially in the Australian Capital Territory and Queensland and Age also contributed a small amount in each State after adjustment. Age appeared to have a larger effect in Victoria even after allowance was made for the other variables.

Sex was clearly even less important as a predictor for the total sample in 1978 than for the restricted sample. This is consistent with the results noted above, with larger sex differences in mean score for the restricted sample. With the exception of Tasmania the variable retained virtually no predictive value after controlling for the effect of the other variables.

Adjusted Mean Scores

As mentioned in the discussion of the MCA procedure, the program calculated adjusted mean scores for each category of each predictor after allowance was made for the influence of the other predictors. The adjusted mean scores for males and females after controlling for the effects of hours of mathematics, age and father's occupation were of interest in this study.

The initial mean scores and corresponding adjusted mean scores for each sub-sample are presented in Table 7.3. The same mean scores are presented graphically in Figure 7.1. In these graphs, the unadjusted mean score on the mathematics test for each sex has been plotted and these points have been joined by a broken line, for ease of interpretation. For each sex the adjusted mean test scores has also been plotted, representing the achievement of the boys or girls after controlling for the other explanatory variables included in the MCA analysis. These points have been linked with an unbroken line. In the interpretation of these scores it should be remembered that the stability of each mean score depends upon the number of cases. Relevant percentages are recorded at the top of the graphs.

By reference to the previous chapter and to the relevant table and figures in the present chapter it is clear that in 1964 and in both samples in 1978 the mean scores obtained by boys were higher than the corresponding mean scores obtained by girls in each State. Adjustments for the confounding effects of the other variable changed this apparently consistent result.

In 1964 after the appropriate corrections were made the mean score for girls was in fact higher than the mean score for boys in both New South Wales and Queensland and much of the difference disappeared in Victoria and Western Australia. In Tasmania, however, the sex difference in favour of the boys increased marginally when adjusted mean scores were calculated. All previous comments about the stability of the Tasmanian results apply and the effect of adjustment emphasizes the poor fit of the model.

Queensland was the only State in which the adjusted mean scores reversed the sex difference to reveal a better performance by girls in the restricted sample of 1978. There were again very little change in Tasmania but in all other States the initial mean scores of girls had been clearly influenced by the other variables. The distribution of categories of the other predictors among girls and boys must have been different. The relative improvement of girls' and deterioration of boys' mean scores was quite dramatic in Western Australia where an initial large difference in favour of boys all but disappeared.

For the total sample in 1978 there was little change in mean scores in the Australian Capital Territory and Tasmania. There was only a small sex difference in mean score in the Australian Capital Territory anyway and the model fitted poorly in Tasmania. In Victoria, Queensland, South Australia and Western Australia the adjustments suggested that girls were really doing 'better' than boys and the same trend was there in New South Wales also.

There are obviously certain State differences involved in the effects that being male or female have on a student's chances for success on these mathematics tests. Thus there is substantial supporting evidence for the view that girls are no less capable of achieving well in higher mathematics than boys. The results presented in this chapter suggest that in both 1964 and 1978 girls were 'penalized' more than boys and somewhat spuriously appeared to perform poorly in comparison with boys When allowance was made for age, father's occupation, and hours spent studying mathematics, the observed sex differences largely disappeared. The adjustment was greater in 1978 than in 1964. Furthermore, in four of the seven total samples under survey in 1978, when allowance was made for these three factors, girls would appear to have achieved at a slightly higher level in mathematics than boys.

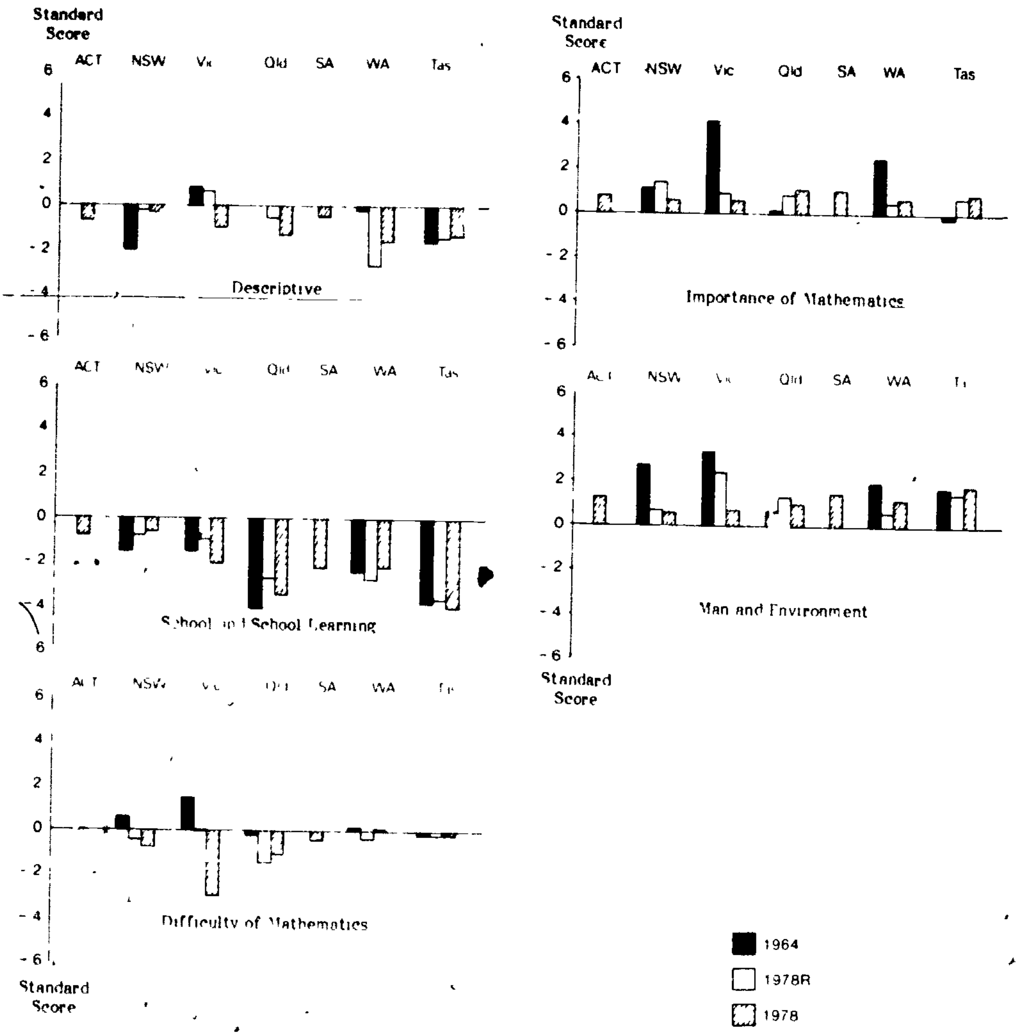

Figure 8.1 Difference Scores Between Standardized Mean Scores of Male and Female Students on Descriptive and Attitude Scales: 1964, 1978R and 1978, Population 1

CHAPTER 8

SEX DIFFERENCES IN ATTITUDES TOWARDS MATHEMATICS

Achievement was not the only aspect of mathematics education investigated in the two IEA mathematics studies. Students also responded to a questionnaire designed to elicit information about their attitudes toward school and toward various aspects of mathematics. It is important to consider sex differences in these attitudes, particularly in the light of the preceding discussion of sex differences in achievement and its possible dependence on differences in attitude.

The development of the original scales has been described by Husén (1967) and the adaptation of the scales for the Second IEA Mathematics Study in Australia has been outlined in Chapter 3 of this report and discussed in more detail by Rosier (1980).

Details of the items constituting each scale are provided in Appendix IV. Rosier (1980) has discussed the changes over time in State mean scores for Population 1 and 3 on each of the Attitude Scales and also the Descriptive Scale. He also discussed changes in student responses to individual scale items. The general picture to emerge was one of considerable consistency of mean scores across States with some differences between population levels as well as between occasions.

Attitudes at the Lower Secondary Level

Table 8.1 presents mean scores by sex and State for the Descriptive Scale, 'Views about Mathematics Teaching'. No data were collected for these items in Queensland in 1964. Table 8.1 also presents the mean scores for the attitudinal scales. These mean scores were used in the calculation of standardized difference scores between the sexes and these scores were calculated in the manner previously described for the mathematics test and sub-tests. These difference scores are presented in Table 8.2 and graphically in Figure 8.1.

Descriptive Scale

It is interesting to note that the boys in the Victorian 1978 total sample had a lower mean score than the corresponding restricted sample. The scale was composed of items such as 'My mathematics teacher wants students to solve problems only by the procedures he or she teaches' and 'My mathematics teacher wants us to discover mathematical principles and ideas for ourselves'. The girls generally held more favourable opinions than the boys. Only in Victoria in 1964 and 1978 (restricted) was this pattern altered and these differences were small. In a large proportion of the schools girls and boys were taught in the same classes suggesting either differential treatment of the sexes or different expectations and interpretations of classroom experiences. The

Table 8.1 Attitude Scales: Mean Scores for Male and Female Students, Population 1

Scale	ACT	NSW	Vic.	Qld	SA	WA	Tas.
School and School Learning (7)[a]							
Male							
1964		15.6	16.1	15.2		16.2	15.4
1978R		14.9	15.3	15.1		14.9	14.8
1978	15.6	14.8	14.8	14.9	14.8	15.1	14.8
Female							
1964		16.1	16.6	16.7		17.1	16.7
1978R		15.2	15.6	16.0		15.9	16.1
1978	15.9	15.1	15.5	16.1	15.6	15.9	16.2
Mathematics as Difficult (5)[a]							
Male							
1964		12.8	13.3	13.0		13.0	12.6
1978R		13.1	13.1	12.8		13.0	13.0
1978	13.2	13.0	12.4	12.8	12.9	13.0	13.0
Female							
1964		12.7	12.9	13.0		13.0	12.6
1978R		13.2	13.1	13.1		13.1	13.0
1978	13.2	13.2	13.1	13.1	13.0	13.0	13.0
Mathematics as Important (6)[a]							
Male							
1964		14.8	15.2	14.5		14.9	14.4
1978R		14.1	14.6	14.1		14.1	14.3
1978	13.8	13.9	13.8	14.2	13.8	14.2	14.3
Female							
1964		14.5	14.0	14.4		14.2	14.5
1978R		13.[illegible]	14.3	1[illegible].9		14.0	14.1
1978	13.6	13.8	14.2	13.9	13.5	14.0	14.1
Man and Environment (4)[a]							
Male							
1964		9.2	9.2	8.9		9.3	9.0
1978R		7.8	8.1	8.0		7.6	8.1
1978	8.0	7.8	7.6	7.9	8.0	7.7	8.1
Female							
1964		8.7	8.6	8.8		8.9	8.7
1978R		7.7	7.6	7.7		7.5	7.8
1978	7.7	7.6	7.5	7.8	7.7	7.4	7.8
Descriptive Scale: Views about Mathematics teaching (5)[a]							
Male							
1964		10.1	9.8	b		9.4	10.0
1978R		10.2	10.3	10.1		9.8	9.9
1978	10.0	10.1	9.7	9.9	0	9 9	9.9
Female							
1964		10.6	9.6	b		9.4	10.5
1978R		10.2	10.1	10.2		10.1	10.3
1978	10.2	10.2	10.0	10.2	10.1	10.1	10.2

a The number of items in the scale is indicated in brackets.
b No data were collected in Queensland in 1964.

Table 8.2 Difference Scores Between Standardized Mean Scores of Male and Female on the Descriptive and Attitude Scales, Population I

Scale	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Descriptive							
1964		-0.20	0.08	a		-0.01	-0.20
1978R		-0.02	0.07	-0.05		-0.27	-0.15
1978	-0.07	-0.03	-0.10	-0.13	-0.05	-0.16	-0.13
School and School Learning							
1964		-0.15	-0.15	-0.41		-0.24	-0.37
1978R		-0.08	-0.09	-0.27		-0.27	-0.36
1978	-0.08	-0.07	-0.21	-0.33	-0.22	-0.22	-0.40
Mathematics as Difficult							
1964		0.05	0.15	-0.02		0.01	-0.02
1978R		-0.05	0.00	-0.15		-0.03	-0.02
1978	0.00	-0.07	-0.29	-0.11	-0.05	0.01	-0.02
Mathematics as Important							
1964		0.11	0.41	0.02		0.25	-0.02
1978R		0.14	0.09	0.09		0.05	0.07
1978	0.08	0.06	-0.13	0.11	0.11	0.07	0.09
Man and Environment							
1964		0.27	0.33	0.07		0.19	0.17
1978R		0.07	0.24	0.13		0.06	0.14
1978	0.13	0.06	0.07	0.10	0.15	0.12	0.18

a No data were collected in Queensland in 1964.

change in differences varied across States, no doubt reflecting different system changes and real variation in curricula and approach.

School and School Learning

Scores on this scale decreased for both sexes in all States between 1964 and 1978, and in most cases the change was greater for girls. Despite this, it is obvious that on no occasion in any State did the boys achieve a higher mean score than the girls. It is also apparent that the sex differences on this scale varied across States being, for example, much larger in Queensland, Western Australia and Tasmania than in New South Wales.

Difficulty of Mathematics

Changes in mean score on this scale were not great. An interesting point was the relatively unfavourable score obtained by boys in the 1978 total sample in Victoria when compared to the restricted sample. This result suggests that the boys in non-government schools considered mathematics to be more difficult than boys in government schools. In most cases, even in 1964, the sex differences on the scale were small. The scale consisted of items such as 'Almost anyone can learn mathematics if he or she is willing to study' and 'Almost all students can learn complex mathematics if it is properly taught'. The 13-year-old girls were of much the same opinion about the difficulty of learning mathematics as the boys, even though few had in the past proceeded to the study of higher mathematics.

Table 8.3 Attitude Scales: Mean Scores for Male and Female Students, Population 3

Scale			ACT	NSW	Vic.	Qld	SA	WA	Tas.
School and School Learning (8)[a]									
	Male	1964		16.5	17.5	16.4		16.2	16.8
		1978R		15.6	16.7	14.9		15.5	17.0
		1978	15.3	15.6	16.3	14.8	15.4	15.1	16.8
	Female	1964		17.5	18.1	18.6		18.5	18.5
		1978R		15.7	17.9	16.3		16.0	17.8
		1978	16.1	16.3	17.8	16.4	16.4	16.4	17.6
Mathematics as Difficult (4)[a]									
	Male	1964		8.0	8.1	8.5		7.8	7.6
		1978R		8.1	8.0	8.1		8.3	8.2
		1978	8.4	8.1	7.8	8.0	7.9	8.3	8.1
	Female	1964		7.0	7.6	7.6		6.7	7.5
		1978R		7.8	7.8	7.3		7.9	8.5
		1978	7.8	7.7	7.5	7.4	7.8	7.8	8.5
Mathematics as Important (6)[a]									
	Male	1964		12.7	12.3	12.5		12.3	13.0
		1978R		11.3	12.4	12.0		11.8	12.0
		1978	11.0	11.2	11.7	11.7	11.5	11.4	12.0
	Female	1964		11.2	12.2	11.7		11.3	12.3
		1978R		10.8	11.6	11.2		10.4	12.0
		1978	10.7	11.3	11.5	11.3	11.2	10.7	11.9
Man and Environment (5)[a]									
	Male	1964		11.0	10.8	11.1		11.5	11.1
		1978R		9.5	9.6	9.3		9.5	9.5
		1978	9.1	9.3	9.6	9.3	9.5	9.6	9.7
	Female	1964		11.2	10.6	10.5		10.9	10.5
		1978R		8.9	9.6	9.6		9.1	9.1
		1978	9.1	9.0	9.4	9.3	9.5	9.3	9.2
Descriptive Scale:									
Mathematics Teaching (4)[a]									
	Male	1964		9.3	8.8	b		8.5	9.3
		1978R		8.2	8.8	8.0		8.5	9.2
		1978	7.7	8.5	8.5	8.0	8.6	8.2	9.3
	Female	1964		9.3	9.7	b		8.6	9.8
		1978R		8.1	8.8	9.0		8.1	9.4
		1978	8.5	8.4	8.5	8.7	8.8	8.5	9.4

a The number of items in the scale is indicated in brackets.
b No data were collected in Queensland in 1964.

Importance of Mathematics

The mean scores of both boys and girls had generally decreased with the exception of the girls in Victoria whose mean score in 1964 was lower than the scores in other States. Although most of the differences were not great the boys regarded mathematics as more important than did the girls in most cases in 1978 as well as in 1964. If girls regard mathematics as unimportant to them, it may be necessary to make them better aware of need for mathematical skills if they are to be encouraged to study mathematics as they grow older.

Man and his Environment

It is clear that sex differences were invariably in favour of the boys. The sex difference has certainly decreased in New South Wales and Victoria where it was very large in 1964. There was also a consistent decrease in mean scores for both sexes, indicating that students in 1978 felt man had less control over the environment through applications of mathematics and science than did their counterparts of 1964.

Attitudes at the Upper Secondary Level

Table 8.3 presents mean scores by sex and State for the Descriptive Scale, 'Views about Mathematics Teaching'. No data were collected for these items in Queensland in 1964. Table 8.3 also presents the mean scores for the attitudinal scales. These mean scores were used in the calculation of standardized difference scores between the sexes. These scores were calculated in the manner previously described for the mathematics test and sub-tests. These difference scores are presented in Table 8.4 and graphically in Figure 8.2.

Descriptive Scale

Most mean scores were lower in 1978 then in 1964. This may reflect changes in the system but it may also reflect a change in student interpretations and views of their classroom experiences. In all States the change was negative and substantial for girls whereas there were mainly small and inconsistent changes for boys. This was an interesting outcome as the schools involved in 1964 and 1978 (restricted) were all government schools and on the latter occasion at least were mainly co-educational. It must be remembered that the girls in 1964 were a very select and possibly atypical group of students. Even in 1978 the large sex differences were in favour of girls. There were obviously considerable state differences in the variation of views of boys and girls on this scale.

School and School Learning

On no occasion did the boys achieve a higher mean score than the girls on this scale. The difference in favour of girls has increased in Victoria but in other States the gap has narrowed, particularly when the restricted sample is considered. This result is probably a function of the changing composition of the Year 12 samples of girls.

Difficulty of Mathematics

Table 8.3 shows that generally positive changes in attitude occurred for Year 12 girls despite the fact that the 1978 samples no longer consisted of such a select group of girls. The girls studying mathematics in 1978 did not regard themselves as special; the scale was comprised of items such as 'Almost all students can learn complex mathematics if it is properly taught'. It is clear that despite the improvement in the

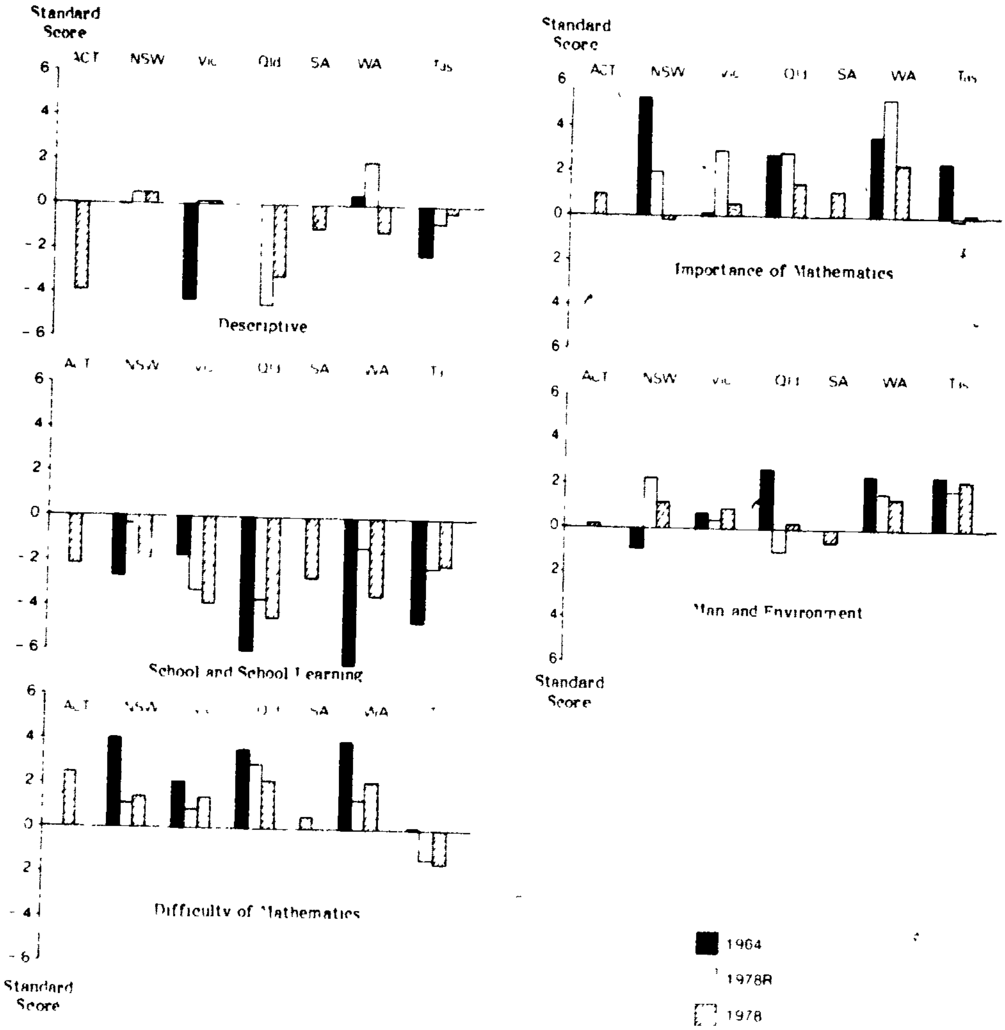

Figure 8.2 Difference Scores Between Standardized Mean Scores of Male and Female Students on Descriptive and Attitude Scales: 1964, 1978R and 1978, Population 3

Table 8.4 Difference Scores Between Standardized Mean Scores of Male and Female Students on the Descriptive and Attitude Scales, Population 3

Scale	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Descriptive							
1964		0.00	-0.43	a		0.05	-0.22
1978R		0.05	0.01	-0.45		0.19	-0.07
1978	-0.39	0.05	0.01	-0.32	-0.10	-0.12	-0.02
School and School Learning							
1964		-0.27	-0.17	-0.61		-0.65	-0.47
1978R		-0.03	-0.33	-0.37		-0.13	-0.22
1978	-0.22	-0.19	-0.39	-0.45	-0.27	-0.35	-0.21
Mathematics as Difficult							
1964		0.40	0.21	0.36		0.40	0.02
1978R		0.11	0.09	0.29		0.14	-0.13
1978	0.25	0.14	0.14	0.21	0.06	0.22	-0.15
Mathematics as Important							
1964		0.53	0.02	0.28		0.35	0.25
1978R		0.19	0.29	0.29		0.53	-0.01
1978	0.10	-0.01	0.07	0.15	0.11	0.24	0.01
Man and Environment							
1964		-0.09	0.07	0.27		0.24	0.24
1978R		0.23	0.03	-0.10		0.16	0.18
1978	0.02	0.12	0.09	0.03	-0.06	0.14	0.22

[a] No data were collected in Queensland in 1964.

girls' attitudes, boys in 1978 still regarded mathematics as less difficult than did girls. Only in Tasmania were the difference scores in favour of girls. The opinion of Year 12 girls may be changing but as yet they do not feel as optimistic about the ease of learning mathematics as boys.

Importance of Mathematics

For both sexes mean scores were generally lower in 1978 with considerable variation across States. On no occasion was the mean score noticeably higher for girls and in Victoria and Western Australia among the government-school samples the difference in favour of boys had increased. Girls studying mathematics at the Year 12 level did not regard the subject as being as important as did their male counterparts. The differences were smaller in the 1978 total sample indicating that the perceptions of boys and girls on this issue differed less in non-government schools.

Man and his Environment

Sex differences were not large on this scale and although generally in favour of boys, this was not invariable even in 1964. Mean scores have decreased for both sexes indicating that students in 1978 felt man had less control over the environment through applications of mathematics and science than those of 1964.

CHAPTER 9

TOWARDS EQUALITY

Over the past decade there has been a very considerable drive to increase the participation by women in a wide range of occupations and positions in society. It was not that there were legal constraints preventing women from entering such occupations or holding such positions, but rather that the expectations of the society in which they lived exerted subtle pressures to preclude their participation. One more formal barrier that has prevented girls from embarking on careers with a scientific basis has been the need to demonstrate competence in mathematics before entering courses of training for such occupations. The emphasis on the provision of greater opportunities for girls and women to enter occupations with a scientific basis, it has been suggested, would lead to greater participation by girls in mathematics courses at school and possibly greater success relative to boys in the study of mathematics.

There has been a long-standing belief in Australian schools, as well as those in other parts of the world, that girls will find the study of mathematics more difficult than will their male coevals. Evidence to support this belief has not been hard to find in the past from sex differences in participation and performance in mathematics courses at the upper secondary school level. However, the nature and origins of these sex differences have been more difficult to establish. There has been a growing acceptance supported by research into such attitudes as fear of success by girls in learning mathematics and relative magnitudes of sex differences in achievement and attitudes in different countries and different settings, that the major causes of these differences lie in societal expectations for the roles of girls and women. In view of the changing perceptions of the roles of women in society that have taken place over the past decade, it was clearly of considerable interest to investigate the changes over time that have occurred in the achievement, attitudes and participation of girls relative to boys in mathematics learning. An opportunity arose through the Second IEA Mathematics Study to replicate in 1978 the program of testing that had taken place in 1964. This report is an account of the issues under investigation and an analysis of the data collected, to examine whether significant changes had occurred in the learning of mathematics at the lower and terminal secondary school levels in Australian schools as a consequence of changing views on greater equality of opportunity for girls and women in our society. It was fortunate that the study had been so designed that it was possible to investigate change in five of the seven state educational systems under survey and so to seek a pattern [illegible] findings of the replicated analyses rather than to [illegible]ly on a single set of data.

Achievement at the Lower Secondary Level

Most previous research into sex differences in achievement in mathematics learning at the lower secondary school level has reported either no differences or an inconsistent pattern of differences in achievement between boys and girls. The findings from this study indicate a slight superiority of girls on tasks associated with lower mental processes in arithmetic and algebra and a higher level of performance by boys on tasks associated with advanced arithmetic and geometry. There was little evidence of change in the patterns of sex differences in learning mathematics across the period of 14 years from 1964 to 1978, and considerable difference in the results reported for the different state systems with a general superiority of boys in Victoria and of girls in the Australian Capital Territory.

Achievement at the Upper Secondary Level

At the terminal secondary school level for students taking courses in mathematics which would enable them to continue with the study of the subject in tertiary institutions, there was generally a clear sex difference in performance with boys achieving at a higher level than girls. This was consistent with the previous research which has indicated that sex differences in mathematics achievement develop during the years of secondary schooling. It was also found that for both the total score and for several of the sub-tests there had been an increase in the difference between the mean scores for boys and the mean scores for girls from 1964 to 1978, the boys doing relatively better in 1978 than in 1964. On the surface this result would appear to be contrary to expectations. However, such superficial differences are misleading and may in part have been influenced by changes in matriculation regulations associated with the study of mathematics and also by curriculum changes that were not necessarily the same across the State systems. Indeed, there were some interesting differences between the States in the sex differences in achievement in the mathematics total tests and the sub-tests. For example, there were very small sex differences in the Australian Capital Territory, while there were in general large sex differences in performance in the areas of algebra, relations and functions and computation in many parts of Australia.

Participation and Holding Power

The major problem associated with understanding the finding that the sex differences in achievement at the terminal secondary school level, in favour of the boys, were larger in 1978 than they had been in 1964 was that the participation rates both at the Year 12 level and in the study of mathematics at this level had changed markedly during that period. Consequently comparison of mean scores loses much of its relevance, if related to populations with substantially different characteristics. In making allowance for the different changes in participation rates for boys and girls at the Year 12 level between 1964 and 1978, a study of the relationships associated with holding power and mathematical yield was undertaken. There had been a very marked increase in the participation by girls in schooling at the Year 12 level over the period of 14 years. Where formerly boys had dominated the Year 12 classrooms, only in the Australian Capital Territory and New South Wales did the numbers of boys exceed the number of girls at school at this level in 1978. In Victoria, probably as a consequence of the existence of alternative approaches to higher education through courses conducted as tertiary orientation programs in technical colleges, the number of girls greatly exceeded the number of boys at the Year 12 level in schools. Likewise, in participation in mathematics courses that were considered to be preparation for the study of mathematics at the tertiary level, there had been a marked increase in the level of involvement of girls. The evidence suggests that no longer are mathematics classes at this level dominated by boys.

From a study of the relationship between holding power in the seven State systems in mathematics courses at the Year 12 level and on mean total scores recorded for the samples tested both in 1964 and 1978, it was found that mean total score on both occasions was linearly and negatively related to holding power. There is thus evidence that an increase in participation in mathematics courses does lead to a decline in average level of performance. However, from the graphs recorded for 1964 and 1978 there was also clear evidence that the growth in participation in mathematics courses between the two occasions had not led to the expected decline in performance, since the graph had been displaced in such a way as to indicate a marked increase in average level of performance across all systems.

Mathematical Yield

In making allowance for differences in holding power on level of student performance the concept of mathematical yield was employed. The measures of mathematical yield take into account the proportion of the grade cohort studying the subject and are concerned with the question 'How many of the students of mathematics are brought how far in their learning of mathematics?'. While there are several debatable assumptions involved in the calculation of indices of yield, the evidence provided by the use of this approach indicated quite clearly that although there had been a noticeable increase in the mathematical yield for boys between 1964 and 1978, there had been very substantial increases in the yield for girls between the two occasions. Indeed, it was apparent that, in general terms, the level of yield for girls in 1978 was approximately equivalent to that for boys in 1964. Clearly it would be desirable to continue to monitor the changes that are occurring to determine whether the gap between the sexes in output of students prepared and trained for the further study of mathematics courses at the tertiary level is continuing to close. The consequence of the marked increase in mathematical yield for girls with regard to increased accessibility to an increased range of scientifically based courses at the tertiary level and for careers in prestigious occupational fields cannot be denied. Thus there is undisputed evidence that, over the period of 14 years, the girls have moved towards a position of greater equality of opportunity in scientifically-based occupations and careers.

When Other Things are Equal

It is always possible that girls will never succeed in catching up with boys in level of performance in mathematics, whether measured by mean scores or by a more complex index such as that of yield. Comparisons between the sexes in mean level of achievement is of course confounded by the many related factors which are also believed to influence achievement. However, it is possible by statistical procedures to make allowances for the effects of such factors and so to examine sex differences in achievement after other things have been taken into account or made equal. Three factors were considered to be of importance in a more detailed examination of sex differences in achievement. Three factors were identified as being likely to have a substantial influence on mean scores for groups of male and female students within each State system. These factors were father's occupation, age, and hours of mathematics learning. In general, the unadjusted coefficients indicating the magnitudes of the sex differences in achievement (the Eta coefficients) were larger for the 1978 samples than for the 1964 samples as would be consistent with the increased sex differences in achievement between the two occasions reported above. However, after adjustment these coefficients (the Beta coefficients) were greatly reduced in magnitude and more so for the 1978 samples than for the 1964 samples, although the Tasmanian sample appeared to be exceptional insofar as the adjusted coefficient exceeded the unadjusted coefficient in 1964. Indeed, the adjusted coefficients for the 1978 total samples for all systems except Tasmania were so small as to be of little practical consequence. It was found further that in four out of the seven cases for the total samples obtained in 1978, that after adjustment, the levels of performance of the female groups exceeded those of the male groups. It is clear from this evidence that after allowance is made for the three factors, father's occupation, age, and hours of mathematics learning there is no evidence for sex differences in achievement in mathematics at the terminal secondary school level. The factors, father's occupation and age are clearly ones over which the school system has little control. However, hours of mathematics learning is a factor, which is not only the most powerful but also the one which might be considered to be malleable and more readily amenable to intervention programs. Before considering the possibility of programs of intervention it is necessary to examine the evidence available for the study of sex difference in attitudes towards mathematics and the learning of mathematics.

Views and Attitudes towards Mathematics Learning

While many of the sex differences in views and attitudes towards mathematics learning recorded in 1964 and 1978 were not statistically significant there was a striking degree of consistency in the findings on the two occasions, across the seven State systems under survey and at the two age levels. It was of some interest to find that girls at both age levels were, in general, more inclined than boys to view the teaching of mathematics as emphasizing problem solving procedures rather than rote learning. Moreover, at both age levels girls held more favourable views of school and school learning, a finding that is consistent with the increasing tendency of girls to stay longer at school than boys. Furthermore, at the lower secondary school level, there was little difference between the sexes in their attitudes towards the difficulty of learning mathematics except in Victoria where there was a striking difference between the samples drawn on the two occasions. In contrast, at the terminal secondary school level, with the exception of the students in the Tasmanian sample in 1978, the boys regarded mathematics more favourably as a subject that could be learnt by most people rather than being a highly specialized subject. At both age levels there was striking consistency in the results recorded that boys held more favourable attitudes as to the importance of mathematics for employment and for understanding of the environment. Likewise at both age levels, in general, boys held more favourable views on the extent to which people could exercise control over their physical environment.

It is easy to express reservations about the use of attitude and descriptive scales such as those employed in this investigation, arguing perhaps that they lack validity and are prone to the making of agreement responses by certain sub-groups. Nevertheless, there is a high degree of consistency in the results reported, and it was clear that it was not always one sex group or the other that held the more favourable attitudes. The evidence presented would appear to support the contention that boys believe more commonly than do girls, that man has more control over his environment and that learning mathematics is of greater importance both as preparation for a suitable occupation and for understanding the environment. There is, however, a change in the views of boys with respect to girls in the difficulty of learning mathematics between the lower and the upper secondary school levels. Whereas at the lower secondary school there is little difference between the sexes in their attitudes, at the upper secondary level boys believe more than do girls that mathematics is a subject that can be learnt by most people. It is of some interest to note that girls are more likely than are boys to perceive the teaching of mathematics as emphasizing problem-solving procedures. Perhaps it is from this perception that their generally less-favourable attitudes towards mathematics learning are derived.

Towards Further Change

There have not been substantial gains in the average level of achievement in mathematics learning of girls relative to boys over the period of 14 years from 1964 to 1978. Nor have there been significant changes in attitudes towards the learning of mathematics. In addition, there is superficial evidence to suggest that at the terminal secondary school level, the achievement of girls relative to boys in mathematics would appear to have declined over the 14 year period. Nevertheless, there has been a marked change over the years from 1964 to 1978 in the degree of involvement and participation by girls in learning mathematics at the upper secondary school level. This is largely a consequence of the trend on the part of girls to stay longer at school. Thus girls who were formerly leaving school prior to Year 12 are staying on at school and more girls are continuing with the study of mathematics courses at this level that would permit them to continue with further learning of mathematics at a tertiary institution. As a consequence the mathematical yield of the school system with respect to the girls in the schools has increased very significantly.

It is argued that this trend on the part of girls to stay longer at school and to continue with the further study of mathematics is a consequence of the changing perceptions within Australia of the role of women in society. However, further change is clearly required if girls are to have equal opportunities with boys to embark upon careers that require scientific and mathematical training. If over a period of the past 14 years some change can occur, then further change would appear to be possible. It is contended that in order to effect further change it will be necessary to change the attitudes held by girls with respect to the importance of learning mathematics for their future careers, to the belief that Man has greater control over his environment than they presently accept, and to the belief that mathematics is not as difficult a subject to learn as they had formerly supposed. It would appear that the more favourable attitudes influence their behaviour. Consequently, it is consistent to argue that changes in attitudes towards learning mathematics must precede changing practice, or at least proceed simultaneously with such change.

Movement towards greater equality between the sexes would appear to have taken place over the period under review. When other things which influence achievement in mathematics are taken into account, the group sex differences in achievement at the terminal secondary school level, in general, disappear. It would now appear necessary for teachers of mathematics, student counsellors, parents and all who influence st ent attitudes, such as the media, to become convi d that an attitude change is possible, that girls, if they so wish, can be as successful as boys in the learning of mathematics. It is suggested that if there is an increased level of participation in the study of mathematics and a greater willingness to spend an equivalent amount of time as do boys in the learning of mathematics, then the differences between the sexes in achievement in mathemati . dually disappear.

There mains from the evidence collected in this investigation one area of concer Why is it that girls appear to view the learning of mathematics as involving, to a grea degree, problem-solving tasks than do boys? Furthermore why is it that while girls generally show a higher level of achievement on tasks involving lower mental processes, basic arithmetic and a' ebra at the lower secondary school level, boys perform better on tasks that involve advanced arithmetic, geometry and higher mental processes? It should be noted that there is little to choose between the sexes in their performance on the total mathematics test at the lower secondary school level. As a consequence girls would not appear to be in a less than satisfactory position to continue with the study of mathematics as they proceed through secondary school. Nevertheless, their failure to do so at present must clearly be linked to the attitudes they hold towards the learning of mathematics, and their apparent reluctance to engage in problem solving tasks.

If intervention programs are to be developed to promote greater involvement and participation by girls in learning mathematics during the secondary school years, then such programs will need to address the issues associated with changing the attitudes of girls towards mathematics and towards engaging in problem-solving tasks.

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APPENDIX I

MATHEMATICS TEST AND SUB-TEST STATISTICS FOR POPULATION 1

Table A.1 Sub-test Mean Scores and Standardized Change Scores for Male and Female Students, Population 1

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Basic Arithmetic (20)[a]							
Male							
1964		9.5	10.3	11.9		9.3	8.2
1978R		8.9	8.9	10.6		9.6	8.5
1978	10.3	9.4	9.6	11.1	10.1	10.0	8.7
Change 1978R-1964		-0.14	-0.32	-0.30		0.07	0.07
Female							
1964		9.6	10.3	12.3		9.2	8.9
1978R		9.5	8.3	11.5		9.8	8.9
1978	11.4	9.7	8.9	11.6	9.9	10.0	9.3
Change 1978R-1964		-0.02	-0.45	-0.18		0.14	
Advanced Arithmetic (15)							
Male							
1964		6.5	6.6	7.1		6.1	5.7
1978R		5.6	5.7	6.4		5.7	5.4
1978	6.5	5.8	6.0	6.8	6.4	6.0	5.5
Change 1978R-1964		-0.32	-0.32	-0.25		0.14	-0.11
Female							
1964		6.2	5.8	6.8		5.4	5.2
1978R		5.5	4.9	6.3		5.7	5.0
1978	6.5	5.5	5.2	6.4	5.6	5.8	5.2
Change 1978R-1964		-0.25	-0.32	-0.18		0.12	-0.07
Algebra (19)							
Male							
1964		6.8	6.6	6.9		6.4	6.0
1978R		6.1	5.9	7.0		6.6	6.0
1978	7.2	6.6	6.4	7.4	6.6	6.8	6.2
Change 1978R-1964		-0.21	-0.21	0.03		0.06	
Female							
1964		7.1	6.8	7.4		6.4	6.2
1978R		7.1	5.5	7.7		6.7	6.0
1978	8.2	7.1	6.0	7.8	6.5	6.9	6.3
Change 1978R-1964		0.0	-0.38	0.09		0.09	-0.06
Geometry (11)							
Male							
1964		4.7	4.9	4.8		4.5	4.0
1978R		3.8	3.7	4.3		4.4	3.7
1978	4.3	4.0	4.0	4.4	4.2	4.[illegible]	3.7
Change 1978R-1964		-0.41	-[illegible]55	-0.23		-0.05	-0.14
Female							
1964		4.5	4.5	4.3		4.1	3.3
1978R		3.9	3.2	4.2		3.9	3.4
1978	4.5	3.9	3.2	4.2	3.9	3.9	[illegible].6
Change 1978R-1964		-0.27	-0.59	-0.05		-0.09	0.05

Table A.1 (continued)

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Lower Mental Processes (37)							
Male							
1964		16.9	17.7	19.0		16.5	14.7
1978R		15.3	15.0	17.7		16.9	14.7
1978	17.5	16.2	16.2	18.4	17.1	17.5	15.1
Change 1978R-1964		-0.21	-0.36	-0.17		0.05	0.0
Female							
1964		17.3	17.8	19.4		16.0	15.1
1978R		16.8	14.0	19.0		17.0	15.2
1978	19.4	16.9	14.9	19.2	16.8	17.4	15.9
Change 1978R-1964		-0.07	-0.51	-0.05		0.14	0.01
Higher Mental Processes (28)							
Male							
1964		10.5	10.7	11.7		9.9	9.2
1978R		9.1	9.2	10.6		9.4	8.8
1978	10.7	9.5	9.7	11.3	10.1	9.7	8.9
Change 1978R-1964		-0.28	-0.29	-0.22		-0.10	-0.08
Female							
1964		10.1	9.6	11.4		9.1	8.5
1978R		9.2	7.8	10.7		9.1	8.0
1978	11.1	9.2	8.3	10.8	9.2	9.2	8.4
Change 1978R-1964		-0.18	-0.35	-0.14		0.00	-0.10

[a] The number of items in the test and sub-tests is indicated in brackets.

MATHEMATICS TEST AND SUB-TEST STATISTICS FOR POPULATION 3

Table A.2 Sub-test Mean Scores and Standardized Change Scores for Male and Female Students, Population 3

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Algebra (20)[a]							
Male							
1964		7.2	8.2	7.7		6.1	9.2
1978R		8.4	9.9	9.5		7.7	10.4
1978	7.4	7.9	9.7	9.4	9.4	7.1	10.5
Change 1978R-1964		0.41	0.60	0.54		0.54	0.42
Female							
1964		7.4	8.3	7.4		5.3	8.4
1978R		7.1	9.1	8.8		6.3	9.3
1978	7.1	7.5	8.9	8.8	8.2	6.5	9.4
Change 1978R-1964		-0.08	0.27	0.48		0.35	0.32
Geometry (5)							
Male							
1964		3.2	3.3	3.6		3.2	3.4
1978R		2.5	2.7	2.7		2.6	3.0
1978	2.4	2.4	2.6	2.7	2.2	2.5	3.0
Change 1978R-1964		-0.58	-0.51	-0.68		-0.45	-0.27
Female							
1964		2.8	3.0	2.9		2.7	3.1
1978R		2.2	2.4	2.4		2.2	2.8
1978	2.3	2.3	2.5	2.4	2.0	2.3	2.7
Change 1978R-1964		-0.54	-0.45	-0.38		-0.40	-0.23
Co-ordinate Geometry (6)							
Male							
1964		3.2	4.0	3.0		2.4	3.8
1978R		3.3	3.9	3.0		2.9	3.9
1978	2.9	3.1	3.7	3.0	3.3	2.8	3.9
Change 1978R-1964		0.04	-0.02	0.02		0.37	0.08
Female							
1964		2.9	3.4	2.9		2.3	4.0
1978R		2.9	3.5	2.9		2.3	3.5
1978	2.7	3.0	3.5	3.0	3.3	2.4	3.5
Change 1978R-1964		-0.03	0.07	0.02		-0.02	-0.39
Calculus (11)							
Male							
1964		3.8	4.3	3.5		2.1	2.9
1978R		4.0	4.2	2.9		2.7	3.0
1978	2.5	3.7	3.6	3.0	2.9	2.2	3.2
Change 1978R-1964		0.10	-0.02	-0.26		0.28	0.05
Female							
1964		3.4	3.6	3.5		1.4	2.9
1978R		3.0	3.3	2.9		1.3	2.5
1978	2.2	3.4	3.2	2.8	2.7	1.3	2.6
Change 1978R-1964		-0.18	-0.16	-0.29		-0.04	-0.20

Table A.2 (continued)

	ACT	NSW	Vic.	Qld	SA	WA	Tas.
Relations and Functions (12)							
Male							
1964		4.8	5.4	4.2		3.5	4.9
1978R		4.9	5.0	4.2		4.7	5.7
1978	3.6	4.5	4.9	4.3	4.4	4.4	5.9
Change 1978R-1964		0.03	-0.20	-0.01		0.62	0.41
Female							
1964		4.4	5.1	3.9		3.0	5.2
1978R		3.9	4.8	4.0		3.6	5.1
1978	3.3	4.4	4.8	4.1	3.8	3.7	5.2
Change 1978R-1964		-0.26	-0.13	0.05		0.29	-0.06
Logic (6)							
Male							
1964		1.9	2.4	2.3		1.6	3.5
1978R		2.3	2.3	2.8		2.0	3.1
1978	2.2	2.2	2.5	2.9	2.4	1.9	3.1
Change 1978R-1964		0.31	-0.11	0.36		0.28	-0.28
Female							
1964		2.0	2.0	2.2		1.5	3.2
1978R		1.9	2.1	2.6		1.9	3.3
1978	2.1	2.0	2.3	2.7	2.4	1.8	3.3
Change 1978R-1964		-0.02	0.10	0.25		0.25	0.10
Computation (33)							
Male							
1964		13.8	15.1	12.8		10.5	14.8
1978R		13.8	17.2	14.2		12.0	16.5
1978	10.9	12.8	15.9	14.2	15.7	11.0	16.9
Change 1978R-1964		0.00	0.44	0.29		0.32	0.35
Female							
1964		13.2	15.0	12.5		9.2	14.5
1978R		11.1	15.3	12.8		8.9	15.2
1978	10.4	11.9	14.5	12.9	14.3	9.4	15.5
Change 1978R-1964		-0.44	0.06	0.08		-0.06	0.15
Verbal (36)							
Male							
1964		13.7	16.1	14.5		11.4	16.8
1978R		15.6	16.1	15.4		13.9	17.7
1978	13.5	14.6	16.0	15.7	13.6	12.9	18.0
Change 1978R-1964		0.31	0.01	0.15		0.41	0.16
Female							
1964		13.1	14.2	13.2		9.7	16.0
1978R		13.0	14.6	14.3		11.3	15.8
1978	12.6	13.9	15.0	14.7	12.5	11.4	15.8
Change 1978R-1964		-0.02	0.05	0.19		0.26	-0.03

[a] The number of items in the test and sub-tests is indicated in brackets.

APPENDIX III

CATEGORIES OF FATHER'S OCCUPATION FOR USE IN MCA

Codes	Description	New Code
13 - 16	personal, domestic and other service workers, miners, farm and rural workers, labourers	1
07 - 12	clerical and related workers, members of armed services and police force, craftsmen and foreman, shop assistants, operatives and process workers, drivers	2
05 - 06	self-employed, shop proprietors, farmers	3
04	managers	4
01 - 03	upper and lower professionals, graziers	5

APPENDIX IV

ITEMS CONSTITUTING DESCRIPTIVE AND ATTITUDE SCALES

Table A.3 Final Forms of the Descriptive Scale: Views About Mathematics Teaching

		Pop. 1	Pop. 3
2	My mathematics teacher shows us different ways of solving the same problem.	X	X
7	My mathematics teacher wants students to solve problems only by the procedures he or she teaches.	X	X
18	My mathematics teacher encourages us to try 'ind several different methods for solving ticular problems.	X	X
23	My mathematics teacher wants us to discover mathematical principles and ideas for ourselves.	X	X
31	My mathematics teacher explains the basic ideas; we are expected to develop the methods of solution for ourselves.	X	

Table A.4 Final Forms of the Scale: Attitude Toward School and School Learning

		Pop. 1	Pop. 3
1	I generally like my school work.	X	X
6	I dislike school and will leave just as soon as possible.	X	X
15	I am bored most of the time in school.	X	X
16	I enjoy everything about school.	X	X
19	School is not very enjoyable but I can see value in getting a good education.		X
26	The most enjoyable part of my life is the time I spend in school.		X
33	I like all school subjects.	X	X
34	I enjoy most of my school work and want to get as much additional education as possible.	X	
36	I find school interesting and challenging.	X	X

Table A.5 Final Forms of the Scale: Attitude Toward Mathematics as Difficult

		Pop. 1	Pop. 3
4	Anyone can learn mathematics.	X	X
21	Almost anyone can learn mathematics if he or she is willing to study.	X	X
25	Any person of average intelligence can learn to understand a good deal of mathematics.	X	
27	Even complex mathematics can be made understandable and useful to every high school student.	X	X
32	Almost all students can learn complex mathematics if it is properly taught.	X	X

Table A.6 Final Forms of the Scale: Attitude Toward Mathematics as Important

		Pop. 1	Pop. 3
10	Mathematics is of great importance to a country's development	X	X
13	Mathematics (algebra, geometry etc.) is not useful for the problems of everyday life.	X	X
17	A thorough knowledge of advanced mathematics is the key to an understanding of our world in the 20th century.		X
20	It is important to know mathematics (algebra, geometry etc.) in order to get a good job.	X	
22	Mathematics is a very good field for creative people to enter.	X	X
24	Unless one is planning to become a mathematician or scientist, the study of advanced mathematics is not very important.	X	X
28	In the near future most jobs will require a knowledge of advanced mathematics.	X	X

Table A.7 Final Forms of the Scale: Attitude Toward Man and His Environment

		Pop. 1	Pop. 3
3	Some day most of the mysteries of the world will be revealed by science.		X
5	By improving industrial and agricultural methods, poverty can be eliminated in the world.	X	X
8	With increased medical knowledge, it should be possible to lengthen the average life span to 100 years or more.	X	X
14	Someday the deserts will be converted into good farming land by the application of engineering and science.	X	X
30	Almost every human problem will be solved in the future.	X	X

Occasional Paper 16